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RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 8, Number 1 January 1967

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the National Center for Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators. These are subject to review by a Board of Editorial Advisors with representatives from the following Federal agencies:

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Published under the direction of

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Dr. Raymond T. Moore, Deputy Director
National Center for Radiological Health

by the Standards and Intelligence Branch,
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Donald L. Snow, Chief

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Address correspondence to the Managing Editor, *Radiological Health Data and Reports*, National Center for Radiological Health, Public Health Service, Rockville, Maryland 20852.

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Reports

A SUMMARY OF EXPOSURES TO THE OFFSITE POPULATION AS A RESULT OF NUCLEAR REACTOR TESTS CONDUCTED AT THE NUCLEAR ROCKET DEVELOPMENT STATION DURING 1965

Donald T. Oakley¹

A summary of whole-body and thyroid exposures resulting from five nuclear-reactor experiments conducted at the Nuclear Rocket Development Station during 1965 is presented. The exposures are compared with protection standards and it is shown that the exposures are small compared to the standards.

During 1965, five releases of radioactivity from the Nuclear Rocket Development Station (NRDS), were detected in the offsite area: the releases from the Kiwi Transient Nuclear Test reactor safety experiment, Experimental Plans 4, 5, and 6 of the NRX-A3, and Experimental Plan 4 of Phoebus 1-A. As a part of the Rover program, testing and disassembling of a series of reactors designated Phoebus and Nerva are being conducted at the NRDS. This work is being administered by the Space Nuclear Propulsion Office. The reactors are tested in an upright position so that the hydrogen coolant is exhausted upward along with escaping fission products. A summary of exposures from the tests is presented in the following tables; additional information may be found in the surveillance reports on each test (1-3). A summary of reactor test data pertinent to the surveillance is presented in table 1.

Whole-body exposure

Monitors equipped with survey instruments recorded exposure rates due to cloud passage. From a plot of dose rate versus time, the exposure due to cloud passage has been estimated. In addition, an estimate of the infinite external

¹ Mr. Oakley, formerly reactor project officer on the staff of the Southeastern Radiological Health Laboratory, is now attached to the Training Branch, National Center for Radiological Health, PHS, and is currently attending the University of Michigan.

January 1967

Table 1. Reactor test data

Test	Date time	Nominal operating power (megawatts)	Integral power (megawatt-seconds)
Kiwi TNT *	1/12/65 1058 PST	Transient ¹	9.4×10^3
EP-4...	4/23/65 1254-1258 PDT	1,100	3.2×10^3
EP-5...	5/20/65 1032-1046 PDT	1,100	1.0×10^3
EP-6...	5/28/65 1030-1100 PDT	<500	4.3×10^3
Phoebus 1-A, EP-4...	6/25/65 1315-1326 PDT	1,100	7.1×10^3

* Kiwi Transient Nuclear Test

exposure has been made by assuming an exposure rate decay from a residual dose rate following cloud passage. An $A_1 T_1^{-1.2} = A_2 T_2^{-1.2}$ decay relationship was assumed for Kiwi Transient Nuclear Test data; for the Phoebus 1-A test is a measured value of $t^{-1.15}$ was employed. The calculation does not consider the influence of an occupancy factor or of weathering, and thus will be conservative. A summary of the peak exposures at populated locations is presented in table 2. The infinite doses following EP-4 and EP-5 are given as zero; any actual deviation from this is very small.

Thyroid dose due to inhalation

Concentrations of iodine-131 and iodine-133 in air were detected following each experiment.

Table 2. Summary of potential whole-body exposures resulting from 1965 NRDS testing

Event	Location of peak dose ^a	External whole-body gamma exposure (milliroentgens)		
		Due to cloud passage	Due to deposition (infinite external exposure)	Total exposure
Kiwi TNT ^b	Death Valley, Jet	0.23	0.44	0.67
	Hwy 95, 1.5 miles west of Lathrop Wells (unpopulated)	5.7	8.5	14.2
EP-4	Pahrump	<0.03	0	<0.03
EP-5	Goss Ranch	<0.03	0	<0.03
EP-6	No measurable dose rates off the test range complex			
Phoebus 1-A, EP-4	Diablo	0.04	1.20	1.24

^a See figure 1

^b Kiwi Transient Nuclear Test

A summary of the peak concentrations of radioiodine, as detected by the use of charcoal cartridges, is presented in table 3. As seen from table 3, a measured thyroid dose following Kiwi Transient Nuclear Test does not compare well with the calculated value. To a large degree, this can perhaps be accounted for by the retention of a fraction of the radioiodine that was available in particulate form, and thus collected by the prefilter.

The procedure employed to calculate the thyroid doses from inhalation is presented below. The various factors are obtained from recommendations made by the International Committee for Radiation Protection (6).

$$\frac{\text{Thyroid dose (D) rads}}{\frac{\text{curie-second}}{\text{meter}^3}} = f_a \cdot 3.7 \times 10^{10} \frac{\text{dis}}{\text{sec-curie}}$$

$$\cdot 8.64 \times 10^4 \frac{\text{sec}}{\text{day}} \cdot E \cdot 1.6 \times 10^{-6} \frac{\text{ergs}}{\text{MeV}}$$

$$\cdot B \cdot \frac{1}{m} \cdot \frac{1}{100 \text{ ergs/gram-rad}} \cdot \int_0^\infty e^{-693t/T_e} dt$$

where

f_a = fraction of inhaled iodine that reaches thyroid = 0.23,

E = energy to thyroid/disintegration = 0.23 MeV, for ¹³¹I and 0.54 MeV, for ¹³³I,

B = breathing rate = 2.32×10^{-4} m³/sec, m = mass of thyroid = 20 grams,

and T_e = effective half-life

$$= 7.6 \text{ days for } ^{131}\text{I}$$

$$= 0.87 \text{ days for } ^{133}\text{I},$$

yielding

$$\frac{\text{Rad}}{\frac{\text{curie-sec}}{\text{m}^3}} = 1.97 \times 10^2 \cdot E \cdot T_e,$$

$$\frac{\text{Rad}}{\frac{\text{curie-sec}}{\text{m}^3}} = 3.42 \times 10^2 (^{131}\text{I}),$$

and

$$\frac{\text{Rad}}{\frac{\text{curie-sec}}{\text{m}^3}} = 9.21 \times 10^1 (^{133}\text{I}).$$

Thyroid dose due to milk ingestion

Following three of the experiments conducted at the NRDS there were detectable quantities of iodine-131 in milk collected in the test site environs. As mentioned in the NRX-A3 and Phoebus 1-A reports (2,3), sources others than NRDS reactors could have been responsible for a portion of the activity. If one scales from data prepared by the Federal Radiation Council (4), it is possible to estimate the potential dose to an infant's thyroid from the milk ingestion. The FRC report assumes that a peak concentration of 8,400 pCi ¹³¹I/liter will result in 1 rad to a child's thyroid due to ingestion of milk following the peak level. If one assumes that 25 percent of the dose is delivered prior to the peak being reached, then it can be calculated that 16 mrad to the thyroid result for each 100 pCi ¹³¹I/liter at the time of peak concentration. However, scaling by this method assumes that the contamination was a result of a single event, and it is necessary to consider this possible source of error in judging the dose estimate.

A summary of the milk-sampling results is presented in table 4. Analyses of samples collected in Nevada and southern California following Kiwi Transient Nuclear Test did not indicate the presence of iodine-131. This probably reflects the fact that at the time of the test most of the animals were on stored feed. In addition, samples collected following NRX-A3, EP-4, did not contain radioiodine.

Table 3. Summary of estimated potential adult thyroid doses through inhalation as a result of 1965 NRDS experiments *

Event	Location of peak concentration *	Iodine-131		Iodine-133		Total thyroid dose (mrad)
		pCi-sec/m ³	Millirad ^b to thyroid	pCi-sec/m ³	Millirad ^b to thyroid	
Kiwi TNT *	Death Valley Jet	ND	0	2.4×10 ³	<0.1	<0.1
	Hwy 95, 1.5 miles west of Lathrop Wells (unpopulated)	8.6×10 ³	0.29	1.7×10 ³	0.16	43.3
EP-4	Pahrump	1.1×10 ³	<0.1	3.4×10 ³	<0.1	<0.1
EP-5	Hiko	3.0×10 ³	<0.1	5.4×10 ³	<0.1	<0.1
	Coyote Summit (unpopulated)	4.0×10 ³	0.14	6.0×10 ³	<0.1	<0.2
EP-6	Lathrop Wells	3.6×10 ³	<0.1	4.2×10 ³	<0.1	<0.1
Phoebus 1-A, EP-4	Diablo	6.0×10 ³	<0.1	2.0×10 ³	<0.1	<0.1
	Queen City Summit (unpopulated)	5.5×10 ³	0.19	1.6×10 ³	0.15	0.34

* See figure 1.

^b The thyroid dose conversion factors for iodine-131 and iodine-133 are

$3.42 \times 10^{-7} \frac{\text{mrad}}{\text{pCi-sec/m}^3}$ and $9.21 \times 10^{-8} \frac{\text{mrad}}{\text{pCi-sec/m}^3}$, respectively.

* Kiwi Transient Nuclear Test.

^d Dose determined by *in vivo* counting, monitored at this station. If substantial amounts of radioiodine in the prefilter were assumed to be biologically available, the potential dose based on air concentration would be even higher.

ND, not detectable.

Table 4. Summary of potential thyroid exposures from milk ingestion resulting from 1965 NRDS experiments

Event	Locations where iodine-131 was detected in milk *	Milk radioassay data peak iodine-131 (pCi/liter)	Calculated thyroid exposure (mrad) ^b
EP-5	Hiko	90	15
EP-6	Springdale	70	11
Phoebus 1-A, EP-4	Alamo	50	8
	Hiko	60	9
	Blue Eagle	180	29
	Currant	20	3

* See figure 1.

^b 16 mrad/100 pCi ¹³¹I/liter, at peak.

Conclusions

The levels of radioactivity encountered off the test-range complex as a result of 1965 NRDS tests were small fractions of the AEC Radiation Protection Guides (5). The dose at any one location was limited by the infrequency of testing and the varied directions of the five experiment "hot lines" (figure 1).

By assuming that 1-milliroentgen exposure produces 1 millirad or 1 millirem absorbed dose, a comparison of the 1965 results with the AEC protection standards has been made in table 5.

Table 5. Comparison of AEC protection standards with 1965 NRDS effluent effects

Type of exposure	AEC Radiation Protection Standards for suitable samples of the general population		Maximum potential exposure encountered in the offsite area (millirem)
	Based on exposure to individual (millirem/yr)	Based on average exposure to a suitable population sample (millirem/yr)	
Whole-body	500	170	14.2 (Lathrop Wells unpopulated) 1.2 (Diablo)
Thyroid	1,500	500	29 (Blue Eagle Ranch) 24 (Hiko) *

* Sum of exposures from EP-5 (5/20/65) and Phoebus 1-A, EP-4 (6/25/65).

A comparison of tables 3 and 4 indicates that the contribution to the thyroid exposure from inhalation was negligible. Table 4 shows the potential exposure due to milk ingestion from Schofield Dairy at Hiko and from the Blue Eagle Ranch. The milk from Hiko, representing 150 cows, is potentially capable of delivering a larger integrated dose to a population, although

Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. Although the total diet is the most direct measure of intake of radionuclides, indicator foods may be used to estimate dietary intake where specific dietary data are not available. As fresh milk is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet, it is the single food item most often used as an indicator of the population's intake of radionuclides. Moreover, it is the major source of dietary intake of short-lived radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analyses of the total diet or representative principal food items or groups, combined with appropriate consumption data.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (1-3). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; however, they do provide an indication of when there is a need to initiate careful evaluation of

exposure (3). Additional guidelines are provided by the FRC Protective Action Guides (4) and by the International Commission on Radiological Protection (5,6).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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NATIONAL AND INTERNATIONAL MILK SURVEILLANCE

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide levels in milk.

In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

<u>Program</u>	<u>Period reported</u>	<u>Last presented</u>
Radiostrontium in milk, HASL	July-December 1965	June 1966

1. Pasteurized Milk Network September 1966

*National Center for Radiological Health and
National Center for
Urban and Industrial Health, PHS*

The Public Health Service's Pasteurized Milk Network (PMN), was designed to provide nationwide surveillance of radionuclide concen-

trations in milk through sampling from major milk production and consumption areas. The present network of 63 sampling stations (figure 1) provides data on milk in every State, the Canal Zone, and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1966 issue of *Radiological Health Data and Reports* (1).

The results for the third quarter of 1966



Figure 1. Pasteurized Milk Network sampling stations

Table 1. Average concentrations of radionuclides in pasteurized milk for the third quarter 1966 and September 1966

Sampling location		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Iodine-131 (pCi/liter)		Cesium-137 (pCi/liter)		Barium-140 (pCi/liter)	
		Third quarter 1966	Sept 1966	Third quarter 1966	Sept 1966	Third quarter 1966	Sept 1966	Third quarter 1966	Sept 1966	Third quarter 1966	Sept 1966
Ala:	Montgomery	<5		12	12	0	0	20	15	0	0
Alaska:	Palmer	<5	<5	11	10	0	0	30	25	0	0
Ariz:	Phoenix	<5	<5	3	4	0	0	10	5	0	0
Ark:	Little Rock	<5		24	24	0	0	25	20	0	0
Calif:	Sacramento	<5	<5	4	4	10	0	10	10	0	0
	San Francisco	<5	<5	4	4	0	0	15	15	0	0
C. Z:	Cristobal	<5		4	4	0	0	15	15	0	0
Colo:	Denver	<5	<5	8	7	0	0	15	10	0	0
Conn:	Hartford	<5	<5	12	12	0	0	30	25	0	0
Del:	Wilmington	<5	<5	11	10	0	0	25	20	0	0
D.C:	Washington	<5		10	10	0	0	15	10	0	0
Fla:	Tampa	<5		10	10	0	0	130	125	0	0
Ga:	Atlanta	<5		19	19	0	0	35	30	0	0
Hawaii:	Honolulu	<5	<5	4	4	0	0	20	20	0	0
Idaho:	Idaho Falls	<5	<5	10	8	0	0	20	15	0	0
Ill:	Chicago	<5	<5	9	8	0	0	20	15	0	0
Ind:	Indianapolis	<5	<5	10	9	0	0	15	15	0	0
Iowa:	Des Moines	<5	<5	12	10	0	0	20	25	0	0
Kans:	Wichita	<5	<5	11	10	0	0	10	5	0	0
Ky:	Louisville	<5	<5	16	16	0	0	10	5	0	0
La:	New Orleans	<5	<5	33	28	0	0	55	40	0	0
Maine:	Portland	<5	<5	14	13	0	0	50	35	0	0
Md:	Baltimore	<5	<5	12	12	0	0	20	15	0	0
Mass:	Boston	<5	<5	15	14	0	0	50	35	0	0
Mich:	Detroit	<5	<5	9	9	0	0	20	15	0	0
Minn:	Grand Rapids	<5	<5	12	11	0	0	30	20	0	0
Miss:	Minneapolis	<5	<5	18	17	0	0	25	10	0	0
Mo:	Jackson	<5	<5	20	19	0	0	25	20	0	0
	Kansas	<5	<5	13	15	0	0	10	10	0	0
	St. Louis	10	<5	16	16	0	0	20	15	0	0
Mont:	Helena	<5	<5	10	9	0	0	25	15	0	0
Nebr:	Omaha	<5	<5	12	11	0	0	20	15	0	0
Nev:	Las Vegas	<5	<5	4	4	0	0	10	10	0	0
N.H:	Manchester	<5	<5	18	15	0	0	75	55	0	0
N.J:	Trenton	<5	<5	11	10	0	0	20	15	0	0
N. Mex:	Albuquerque	<5	<5	7	8	0	0	10	10	0	0
N.Y:	Buffalo	<5	<5	10	9	0	0	25	20	0	0
	New York	<5	<5	14	12	0	0	30	20	0	0
	Syracuse	<5	<5	10	9	0	0	25	20	0	0
N.C:	Charlotte	<5	<5	20	20	0	0	25	20	0	0
N. Dak:	Minot	<5	<5	21	21	0	0	25	25	0	0
Ohio:	Cincinnati	<5	<5	11	11	0	0	15	15	0	0
	Cleveland	<5	<5	11	9	0	0	20	15	0	0
Okla:	Oklahoma City	<5	<5	11	11	0	0	15	10	0	0
Ore:	Portland	<5	<5	11	10	0	0	30	25	0	0
Pa:	Philadelphia	<5	<5	15	13	0	0	20	20	0	0
P.R:	Pittsburgh	<5	<5	7	6	0	0	20	20	0	0
P.R:	San Juan	<5	<5	15	12	0	0	40	30	0	0
R.I:	Providence	<5	<5	20	20	0	0	50	45	0	0
S.C:	Charleston	<5	<5	14	11	0	0	15	10	0	0
S. Dak:	Rapid City	<5	<5	20	19	0	0	25	15	0	0
Tenn:	Chattanooga	<5	<5	16	16	0	0	15	10	0	0
Tex:	Memphis	<5	<5	5	6	0	0	10	5	0	0
	Austin	<5	<5	11	11	0	0	15	10	0	0
Utah:	Dallas	<5	<5	9	8	0	0	15	15	0	0
	Salt Lake City	<5	<5	13	10	0	0	35	25	0	0
Vt:	Burlington	<5	<5	16	16	0	0	20	15	0	0
Va:	Norfolk	<5	<5	19	14	0	0	55	45	0	0
Wash:	Seattle	<5	<5	13	11	0	0	30	25	0	0
	Spokane	<5	<5	14	14	0	0	15	10	0	0
W. Va:	Charleston	<5	<5	8	7	0	0	20	20	0	0
Wis:	Milwaukee	<5	<5	9	8	0	0	20	20	0	0
Wyo:	Laramie	<5	<5			0	0	20	10	0	0
Network average		<5	<5	12.5	11.6	0	0	25	20	0	0

* Blank indicates no strontium-90 determinations were made on samples.

Table 1. Average concentrations of radionuclides in pasteurized milk for the third quarter 1966 and September 1966

Sampling location		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Iodine-131 (pCi/liter)		Cesium-137 (pCi/liter)		Barium-140 (pCi/liter)	
		Third quarter 1966	Sept 1966	Third quarter 1966	Sept 1966	Third quarter 1966	Sept 1966	Third quarter 1966	Sept 1966	Third quarter 1966	Sept 1966
Ala:	Montgomery	<5		12	12	0	0	20	15	0	0
Alaska:	Palmer	<5	<5	11	10	0	0	30	25	0	0
Ark:	Phoenix	<5	<5	3	4	0	0	10	5	0	0
Calif:	Little Rock	5		24	24	0	0	25	20	0	0
	Sacramento	<5	<5	4	4	10	0	10	10	0	0
	San Francisco	<5	<5	4	4	0	0	15	15	0	0
C. Z:	Cristobal	<5		4	4	0	0	15	15	0	0
Colo:	Denver	<5	<5	8	7	0	0	15	10	0	0
Conn:	Hartford	<5	<5	11	10	0	0	30	25	0	0
Del:	Wilmington	<5	<5	12	12	0	0	25	20	0	0
D.C:	Washington	<5		11	10	0	0	15	10	0	0
Fla:	Tampa	<5		10	10	0	0	130	125	0	0
Ga:	Atlanta	5		19	19	0	0	35	30	0	0
Hawaii:	Honolulu	<5	<5	4	4	0	0	20	20	0	0
Idaho:	Idaho Falls	<5	<5	10	8	0	0	20	15	0	0
Ill:	Chicago	<5	<5	9	8	0	0	20	15	0	0
Ind:	Indianapolis	<5	<5	10	9	0	0	15	15	0	0
Iowa:	Des Moines	<5	<5	12	10	0	0	20	25	0	0
Kans:	Wichita	<5	<5	11	10	0	0	10	5	0	0
Ky:	Louisville	5		16	16	0	0	10	5	0	0
La:	New Orleans	<5	<5	33	28	0	0	55	40	0	0
Maine:	Portland	<5	<5	14	13	0	0	50	35	0	0
Md:	Baltimore	<5	<5	12	12	0	0	20	15	0	0
Mass:	Boston	<5	<5	15	14	0	0	50	35	0	0
Mich:	Detroit	<5	<5	9	9	0	0	20	15	0	0
	Grand Rapids	<5	<5	12	11	0	0	30	20	0	0
Minn:	Minneapolis	<5	<5	18	17	0	0	25	10	0	0
Miss:	Jackson	5		20	19	0	0	25	20	0	0
Mo:	Kansas	5	<5	13	15	0	0	10	10	0	0
	St. Louis	10	<5	16	16	0	0	20	15	0	0
Mont:	Helena	<5	<5	10	9	0	0	25	15	0	0
Nebr:	Omaha	5		12	11	0	0	20	15	0	0
Nev:	Las Vegas	<5	<5	4	4	0	0	10	10	0	0
N.H:	Manchester	<5	<5	18	15	0	0	75	55	0	0
N.J:	Trenton	<5	<5	11	10	0	0	20	15	0	0
N. Mex:	Albuquerque	<5	<5	7	8	0	0	10	10	0	0
N.Y:	Buffalo	<5	<5	10	9	0	0	25	20	0	0
	New York	<5	<5	14	12	0	0	30	20	0	0
Syracuse:		<5	<5	10	9	0	0	25	20	0	0
N. C:	Charlotte	<5	<5	20	20	0	0	25	20	0	0
N. Dak:	Minot	<5	<5	21	21	0	0	25	20	0	0
Ohio:	Cincinnati	<5	<5	11	11	0	0	15	15	0	0
	Cleveland	<5	<5	11	9	0	0	20	15	0	0
Okla:	Oklahoma City	<5	<5	11	11	0	0	15	10	0	0
Ore:	Portland	<5	<5	11	11	0	0	30	25	0	0
Pa:	Philadelphia	<5	<5	15	13	0	0	20	20	0	0
Pittsburgh:		<5	<5	7	6	0	0	20	20	0	0
P.R:	San Juan	<5	<5	15	12	0	0	40	30	0	0
R.I:	Providence	<5	<5	20	20	0	0	50	45	0	0
S.C:	Charleston	5		14	11	0	0	15	10	0	0
S. Dak:	Rapid City	<5	<5	20	19	0	0	25	15	0	0
Tenn:	Chattanooga	<5	<5	16	16	0	0	15	10	0	0
	Memphis	<5	<5	5	6	0	0	10	5	0	0
Tex:	Austin	<5	<5	11	9	0	0	15	10	0	0
	Dallas	<5	<5	9	8	0	0	15	15	0	0
Utah:	Salt Lake City	<5	<5	13	10	0	0	20	15	0	0
Vt:	Burlington	<5	<5	16	16	0	0	35	25	0	0
Va:	Norfolk	<5	<5	19	14	0	0	55	45	0	0
Wash:	Seattle	<5	<5	13	11	0	0	30	25	0	0
Spokane:		<5	<5	14	14	0	0	15	10	0	0
W. Va:	Charleston	<5	<5	8	7	0	0	20	20	0	0
Wis:	Milwaukee	<5	<5	9	8	0	0	20	10	0	0
Wyo:	Laramie	<5	<5								
Network average		<5	<5	12.5	11.6	0	0	25	20	0	0

* Blank indicates no strontium-89 determinations were made on samples.

Table 2. Frequency distribution, strontium-90 concentrations in milk at Pasteurized Milk Network stations, September 1965 and April-September 1966

Strontium-90 (pCi/liter)	Number of stations						
	1965	1966					
	Sept	Apr	May	June	July	Aug	Sept
Under 10.....	11	8	10	9	14	15	21
10-19.....	44	50	38	41	39	40	37
20-29.....	7	3	12	10	9	7	5
30-39.....	1	2	3	3	1	1	0

Table 3. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations, September 1965 and April-September 1966

Cesium-137 (pCi/liter)	Number of stations						
	1965	1966					
	Sept	Apr	May	June	July	Aug	Sept
Under 50.....	50	55	51	56	56	56	61
50-99.....	12	7	11	6	6	6	1
100-149.....	0	1	1	1	1	1	1
150-199.....	1	0	0	0	0	0	0

and September 1966 are presented in table 1. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations (1), averages were calculated using one-half the minimum detectable value; however, for iodine-131 and barium-140, zero was used for

averaging purposes when concentrations were below minimum detectable levels.

For comparative purposes, distributions of strontium-90 and cesium-137 are presented in tables 2 and 3 for September 1965 and April through September 1966. The average strontium-90 concentrations in pasteurized milk from selected cities are presented in figure 2.

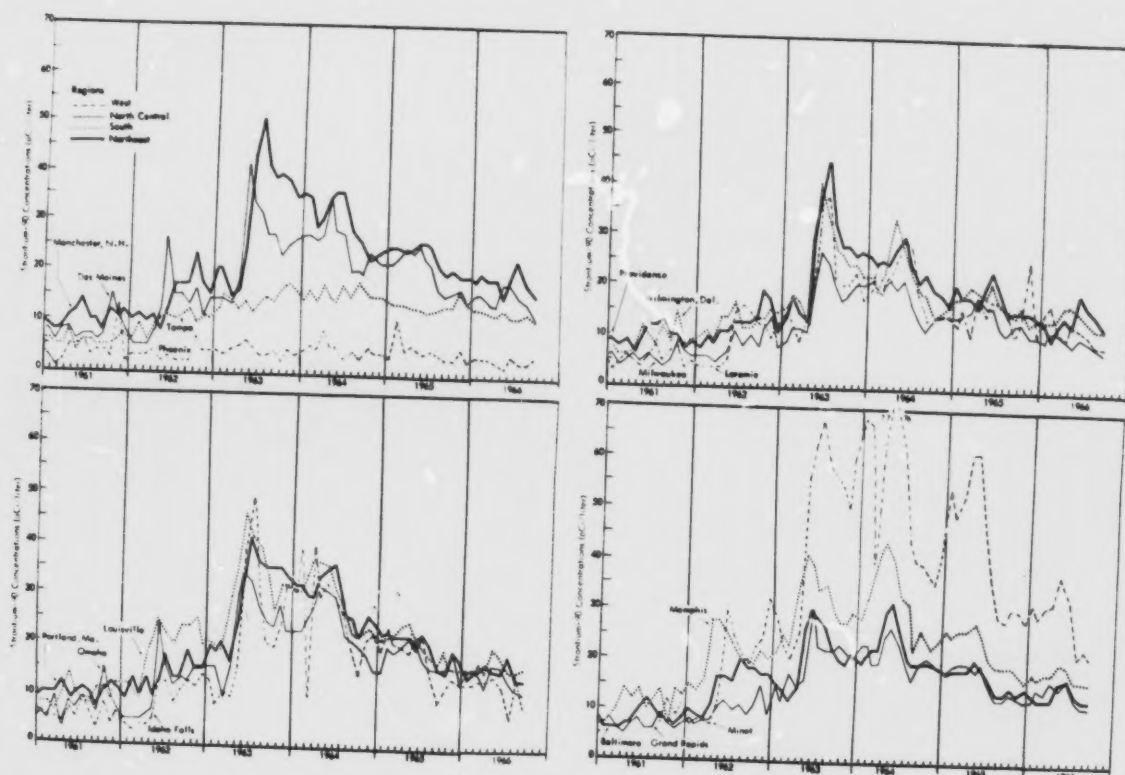


Figure 2. Strontium-90 concentrations in pasteurized milk, 1961-September 1966

2. Canadian Milk Network September 1966¹

Radiation Protection Division
Department of National Health and Welfare

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk-sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine-131, and monthly composites are analyzed for strontium-90, cesium-137, and stable calcium and

potassium. The analytical procedures were outlined in the December 1966 issue of *Radiological Health Data and Reports* (2).

The September 1966 monthly average strontium-90, cesium-137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 4. Iodine-131 and strontium-89 concentrations were below minimum detectable levels.

Table 4. Stable elements and radionuclides in Canadian whole milk, September 1966

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.12	1.6	15.9	34
Edmonton	1.10	1.5	14.4	37
Ft. William	1.06	1.4	16.7	44
Fredericton	1.12	1.5	14.4	38
Halifax	1.14	1.5	16.6	41
Montreal	1.08	1.4	12.3	22
Ottawa	1.17	1.4	8.9	22
Quebec	1.08	1.6	18.2	40
Regina	1.10	1.5	12.4	23
St. John's, Nfld.	1.09	1.5	31.7	79
Saskatoon	1.12	1.5	11.2	28
Sault Ste. Marie	1.06	1.5	16.7	36
Toronto	1.15	1.5	5.2	16
Vancouver	1.14	1.5	18.7	87
Windsor	1.10	1.5	6.3	17
Winnipeg	1.08	1.5	10.1	37
Average	1.11	1.5	14.4	38

¹ Prepared from September 1966 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.



Figure 3. Canadian milk sampling stations

3. Pan American Milk Sampling Program September 1966

*Pan American Health Organization and
U.S. Public Health Service*

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between both agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (3).



Figure 4. Pan American Milk Sampling Program locations

Table 5 presents stable calcium and potassium, strontium-89, strontium-90, and cesium-137 monthly average concentrations for September 1966.

Table 5. Stable element and radionuclide concentrations in PAHO milk, September 1966 *

Sampling station	Number of samples	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Chile:					
Santiago.....	4	1.16	1.60	2	6
Colombia:					
Bogota.....	4	1.16	1.46	3	5
Ecuador:					
Guayaquil.....	4	1.10	1.57	2	5
Jamaica:					
Kingston.....	NS				
Mandeville.....	NS				
Montego Bay.....	1	1.21	1.31	13	300
Venezuela:					
Caracas.....	1	1.10	1.49	6	<5
February, 1966.....	1	1.10	1.38	4	20
Canal Zone:					
Cristobal.....	1	—	—	4	15
Puerto Rico:					
San Juan.....	1	—	—	6	20

* Strontium-89 determinations were less than 5 pCi/liter; iodine-131 and barium-140 determinations were less than 10 pCi/liter for all samples.
NS, no sample collected.

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- (2) CANADIAN DEPARTMENT OF NATIONAL HEALTH AND WELFARE, RADIATION PROTECTION DIVISION. Canadian Milk Network, August 1966. Radiol Health Data Rep 7:702-703 (December 1966).
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STATE MILK SURVEILLANCE ACTIVITIES

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have progressed to a state of comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk

surveillance activities. State milk surveillance activities are continually undergoing developmental changes at this time. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

In addition to the State milk networks presented herein, programs previously covered in *Radiological Health Data and Reports* include:

State milk network	Period reported	Last presented
California	April-June 1966	December 1966
Colorado	January 1965-June 1966	October 1966
Connecticut	April-June 1966	November 1966
Florida	April-June 1966	October 1966
Indiana	April-June 1966	November 1966
Michigan	January-June 1966	November 1966
Minnesota	April-June 1966	November 1966
New York	January-June 1966	November 1966
Oregon	April-June 1966	December 1966
Pennsylvania	April-June 1966	November 1966
Washington	April-June 1966	December 1966

1. Oklahoma Milk Network July-September 1966

*Oklahoma State Department of Health*¹

On March 15, 1965, the Radiological Health Section of the Oklahoma State Department of Health initiated a program of analysis for iodine-131 in the milk produced in the State of Oklahoma. On March 7, 1966, analysis for cesium-137 was added to the program.

¹ Acknowledgment is accorded to the staff of the Radiological Health Section under the direction of Mr. Dale McHard, head, and Mr. Robert Craig, assistant engineer.

The location of the sampling stations and the extent of their associated milksheds are shown in figure 1. Of the 10 milksheds in the State of Oklahoma, 5 were chosen as sampling stations (Oklahoma City, Enid, Tulsa, Lawton, and Ardmore) on the basis of their size and location. A major criterion in the selection of a milkshed for sampling was the degree of overlap with other milksheds being sampled. This overlap assists in locating small areas of production where the iodine-131 concentrations might be abnormally high.

The sampling stations are located in the laboratory of a major milk-processing plant in each milkshed. While the milkshed for a par-

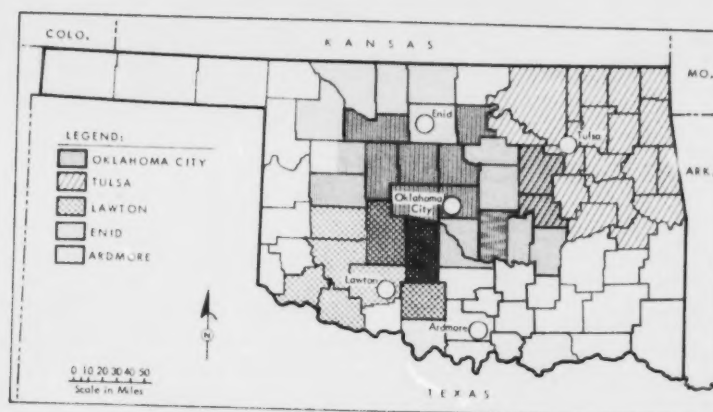


Figure 1. Oklahoma milkshed sampling areas

particular processing plant may not coincide exactly with that shown in figure 1, the coincidence is satisfactory for surveillance purposes.

At the present time, samples are collected on Monday morning, and the analyses are completed by Wednesday afternoon. However, if iodine-131 levels detected are such that diversion of the milk or other precautionary methods need to be taken, the analytical method and equipment can be employed to sample milk from each truck arriving at the processing plant. Under these conditions, only about 4 hours would be needed to complete the analysis. This greatly reduced lag time for analysis would permit rapid decisions on the fate of each truckload of raw milk.

The ion exchange method of analysis used is similar to that recently published by the Public Health Service (1), but was developed independently by the Oklahoma State Health Department's Radiological Health Laboratory. Details of the procedure used were published earlier (2).

Table 1 gives the cesium-137 concentrations in Oklahoma milk for the period of July through September 1966. Iodine-131 was found in only three samples during this period. These concentrations are shown in table 2.

Table 1. Concentration of cesium-137 in Oklahoma milk July-September 1966

Sampling date	Sampling location				
	Oklahoma City (pCi/liter)	Enid (pCi/liter)	Tulsa (pCi/liter)	Lawton (pCi/liter)	Ardmore (pCi/liter)
July 4.	24	• 15			
11.	ND	• 13	NS	14	11
18.	23	• 22	9	21	ND
25.	NS	• 23	30	35	22
			25	30	21
August 1.	ND	• 11	ND	18	ND
8.	32	• 24	24	25	22
15.	27	• 21	21	28	23
22.	26	• 27	NS	23	27
29.	23	• 18	15	23	26
September 5.	19	• NS	13	25	NS
12.	NS	• NS	13	32	17
19.	20	• 16	NS	19	24
26.	NS	• 20	NS	NS	NS

* Samples split with PHS Pasteurized Milk Network.
NS, no sample collected
ND, not detectable

Table 2. Concentration of iodine-131 in Oklahoma milk July-September 1966

Date 1966	Sampling station	Concentration (pCi/liter)
July 25.....	Ardmore	7
August 15.....	Oklahoma City *	6
September 12.....	Tulsa	45

* Samples split with PHS Pasteurized Milk Network.

Previous coverage in *Radiological Health Data and Reports*:

Period
March-July 1965
August-December 1965
January-March 1966
April-June 1966

Issue
October 1965
April 1966
July 1966
October 1966

2. Texas Milk Network July–September 1966

Texas State Department of Health

The Texas State Department of Health initiated a statewide milk sampling network for radionuclide content in April 1964. At present, monthly samples of raw milk are collected from each of six "active" sampling points. In addition, six "standby" stations have been supplied sample containers and shipping instructions and can be activated immediately if needed. The "active" and "standby" station locations, shown in figure 2, were chosen to give maximum geographical and population coverage.

* Acknowledgment is accorded to the staff of the Radiation Control Program, Division of Occupational Health and Radiation Control, under the direction of Mr. Martin C. Wukasch, chief engineer.

Samples are routinely analyzed for strontium-89 and strontium-90 by a chemical-separation technique employing ion exchange columns (3).

Potassium-40, iodine-131, and barium-140 concentrations are determined by gamma-scintillation spectrometry. Details of the analytical procedures were presented earlier (4).

Table 3 presents the July through September 1966 radionuclide concentrations in Texas milk. During this time, strontium-89 and barium-140 concentrations were below detectable levels. Strontium-90 and cesium-137 concentrations are shown graphically in figure 3 to indicate general trends.

Previous coverage in *Radiological Health Data and Reports*:

Period

1964 Summary
January–March 1965
April–December 1965
January–March 1966
April–June 1966

Issue

June 1965
October 1965
April 1966
July 1966
October 1966



Figure 2. Texas milk sampling stations

Table 3. Radionuclide concentrations in Texas milk network, July-September 1966

Sampling location	Potassium-40 (pCi/liter)			Strontium-90 (pCi/liter)			Iodine-131 (pCi/liter)			Cesium-137 (pCi/liter)		
	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept
Austin	1,210	NS	1,370	5	NS	4	ND	NS	6	10	NS	5
Fort Worth	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
El Paso	1,270	1,250	1,300	4	2	3	ND	ND	ND	5	5	5
Harlingen	1,300	1,270	1,360	2	4	4	ND	ND	ND	10	5	5
Houston	1,290	NS	NS	8	NS	NS	5	NS	NS	NS	NS	NS
Lubbock	1,300	1,220	1,340	5	4	5	20	ND	ND	20	10	10
San Antonio	NS	1,230	1,330	NS	4	3	NS	5	4	NS	10	5
Average	1,275	1,245	1,340	4.8	3.5	3.8	6	1.3	2	14	7.5	6

NS, no sample collected.
ND, below detectable limits.

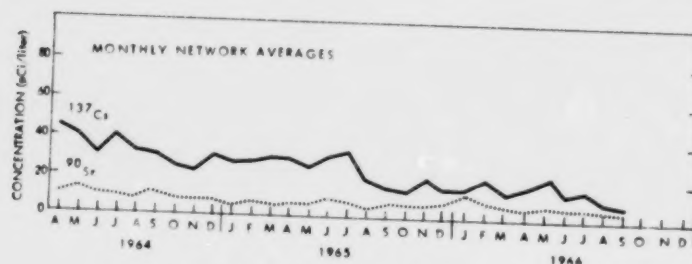


Figure 3. Radionuclide concentrations in Texas milk 1964-September 1966

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- (2) OKLAHOMA STATE DEPARTMENT OF HEALTH. Oklahoma milk network, March-July 1965. Radiol Health Data 6:540-541 (October 1965).
- (3) PORTER, C., and B. KAHN. Improved determination of strontium-90 in milk by ion-exchange method. Anal Chem 36:676-678 (March 1964).
- (4) TEXAS STATE DEPARTMENT OF HEALTH. Texas milk network, January-March 1965. Radiol Health Data 6:541-542 (October 1965).

FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reporting routinely include: (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the

State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Periodically, results from the United Kingdom Diet Survey, conducted by the United Kingdom Agricultural Research Council Radiobiological Laboratory, are presented for comparison with data observed in the United States. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are listed below:

<u>Program</u>	<u>Period reported</u>	<u>Last presented</u>
Connecticut Standard Diet	July 1965-June 1966	November 1966
Teenage Diet, FDA	February-November 1965	August 1966
Tri-City Diet, HASL	February-April 1966	December 1966
United Kingdom Diet, ARCRL	Annual summary 1965	December 1966

1. Radionuclides in Institutional Diet Samples April-June 1966

National Center for Radiological Health Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the National Center for Radiological Health with the assistance of the National Center for Urban and Industrial Health (1).

The program was designed to estimate the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in 50 municipalities. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Subsequent experience with the diets of school children of various ages indicated that the number of institutions sampled could be selectively reduced. As of July 1965, 21 institutions, distributed geographically as shown in figure 1, were being sampled. Previous results showed that the daily intakes of teenage girls and children from 9 to 12 years of age were

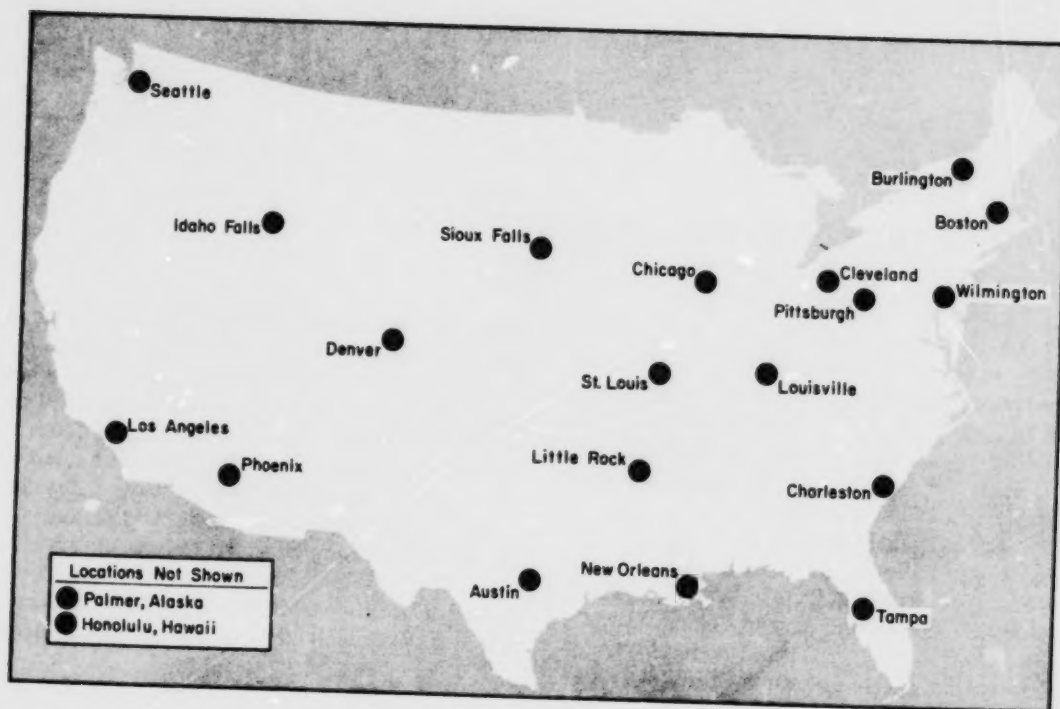


Figure 1. Institutional diet sampling locations as of July 1965

comparable, while teenage boys consumed 20 percent more food per day (1,2). Consequently, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. Each sample supplied monthly by each institution represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks), obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily sample is kept frozen until the end of the collection period, and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nev.; the Southeastern Radiological Health Laboratory, Montgomery, Ala.; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures was presented elsewhere (3).

Results

Table 1 presents the analytical results for institutional diet samples collected from April through June 1966, for children 9 to 12 years of age. The stable elements, calcium and potassium, are reported in g/kg of diet, and the radionuclide concentrations of strontium-89, strontium-90, cesium-137, and radium-226 are expressed as pCi/kg of diet. The reported radionuclide concentrations of these samples are corrected for radioactive decay to the midpoint of the sample collection period, where applicable.

Dietary intakes, presented in table 2, were obtained by multiplying the food consumption rate in kg/day by the concentration values given in table 1. For the purpose of obtaining dietary intakes, "less than" 5 pCi/kg of strontium-89 was interpreted as 2.5 pCi/kg. The average food consumption rate during this period was 1.76 kg/day compared to the network average of 1.90 kg/day observed from 1961 through 1964 (4).

Strontium-90 dietary intake during this period averaged 19 pCi/day. This result falls within Range I as defined by the Federal Radiation Council (5). Cesium-137 intakes averaged 60 pCi/day during this period. Strontium-89, barium-140, and iodine-131 concentrations were generally below detectable levels.

Previous coverage in Radiological Health Data and Reports:

Period

January-March 1964
April-June 1964
July-September 1964
October-December 1964
Annual average 1964
January-March 1965
April-June 1965
July-September 1965
October-December 1965
Annual average 1965
January-March 1966

Issue

October 1964
January 1965
April 1965
July 1965
July 1965
October 1965
February 1966
May 1966
July 1966
July 1966
October 1966

Table 1. Stable element and radionuclide concentrations in institutional total diets of children (9-12 years of age) April-June 1966 *

Location of institution	Month 1966	Stable element, g/kg of diet		Radionuclide concentration, pCi/kg of diet			
		Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Alaska: Palmer	April	0.5	0.8	<5	11	35	0.3
	May	0.6	0.8	<5	21	40	1.9
	June	0.8	1.0	<5	12	35	1.1
Ariz: Phoenix	April	0.5	0.8	<5	7	20	0.7
	May	0.6	1.0	<5	11	20	1.9
	June	0.6	1.3	<5	12	30	0.7
Ark: Little Rock	April	0.6	1.4	<5	12	25	1.3
	May	0.5	1.4	<5	14	30	0.8
	June	0.5	1.5	10	18	25	1.0
Calif: Los Angeles	April	0.9	1.4	<5	7	20	2.4
	May	1.1	1.4	<5	12	25	3.0
	June	0.9	1.5	<5	6	25	1.0
Colo: Denver	April	0.8	1.1	<5	11	30	0.2
	May	0.8	1.3	<5	16	30	0.2
	June	0.9	1.4	<5	16	20	1.0
Del: Wilmington	April	0.6	1.6	<5	9	25	0.6
	May	0.7	1.5	<5	10	25	0.3
	June	0.7	1.7	<5	11	25	0.7
Fla: Tampa	April	0.9	1.7	<5	11	85	2.7
	May	0.6	1.3	<5	9	55	1.1
	June	0.6	1.6	<5	12	80	3.4
Hawaii: Honolulu	April	0.5	1.2	<5	5	40	0.4
	May	0.4	1.2	<5	5	30	0.7
	June	0.4	1.3	<5	5	35	0.4
Idaho: Idaho Falls	April	0.7	1.5	<5	8	30	0.8
	May	1.2	1.5	<5	25	30	0.1
	June	0.7	1.4	<5	6	30	0.7
Ill: Chicago	April	0.7	1.5	<5	8	35	0.6
	May	0.7	1.4	<5	8	40	0.7
	June	0.7	1.4	5	12	30	0.2
Ky: Louisville	April	0.9	1.7	<5	13	25	2.2
	May	0.8	1.9	<5	16	55	1.1
	June	1.0	1.8	10	19	30	2.9
La: New Orleans	April	0.8	1.5	<5	18	40	0.8
	May	0.8	1.6	<5	21	35	0.6
	June	0.6	1.3	<5	22	45	0.8
Mass: Boston	April	0.5	1.3	<5	8	25	0.5
	May	0.6	1.5	<5	7	35	0.7
	June	0.5	1.3	<5	9	30	0.5
Mo: St. Louis	April	0.7	1.5	<5	10	30	0.6
	May	0.8	1.5	<5	12	30	0.7
	June	0.8	1.6	30	17	35	0.2
Ohio: Cleveland	April	0.7	1.6	<5	10	80	0.9
	May	0.6	1.6	<5	7	40	0.7
	June	0.7	1.6	<5	11	30	1.1
Pa: Pittsburgh	April	0.6	1.4	<5	10	35	0.7
	May	0.6	1.2	<5	9	40	1.0
	June	0.6	1.4	<5	11	25	0.7
S.C: Charleston	April	0.7	1.2	<5	13	25	1.3
	May	0.6	1.5	<5	12	25	1.1
	June	0.6	1.3	10	14	50	1.5
S. Dak: Sioux Falls	April	0.8	1.7	<5	17	65	0.8
	May	0.8	1.5	<5	14	40	0.7
	June	1.0	1.7	10	12	35	0.8
Tex: Austin	April	0.5	1.3	<5	6	25	1.6
	May	0.6	1.2	<5	6	15	1.0
	June	0.5	1.2	<5	10	25	1.0
Vt: Burlington	April	0.6	1.6	<5	11	50	0.4
	May	0.7	1.6	<5	16	55	0.6
	June	0.6	1.5	<5	13	40	0.5
Wash: Seattle	April	0.8	1.6	<5	20	65	0.6
	May	0.8	1.7	<5	18	40	0.3
	June	0.8	1.4	<5	29	50	1.3
Institutional average	April	0.7	1.4	<5	11	40	1.0
	May	0.7	1.4	<5	13	35	0.9
	June	0.7	1.4	5	13	35	1.0

* During the second quarter of 1966, both iodine-131 and barium-140 concentrations were below detectable levels at all institutions except for following:
Del: Wilmington June 1966 10 pCi/kg, iodine-131
S. Dak: Sioux Falls June 1966 20 pCi/kg, iodine-131

Table 2. Intake of stable elements and radionuclides in institutional total diet for children (9-12 years of age) April-June 1966

Location of institution	Month 1966	Total weight (kg/day)	Stable element intake, g/day		Radionuclide intake, pCi/day			
			Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Alaska: Palmer.....	April *	1.89	0.9	1.5	5	21	65	0.6
	May *	1.38	0.8	1.1	5	29	55	2.6
	June *	1.71	1.4	1.7	5	21	60	1.9
Ariz: Phoenix.....	April	1.96	1.0	1.6	5	14	40	1.4
	May	2.15	1.3	2.2	5	24	45	4.1
	June	1.71	1.0	2.2	5	21	50	1.2
Ark: Little Rock.....	April	1.19	0.7	1.7	5	14	30	1.5
	May	1.96	1.0	2.7	5	27	60	1.6
	June	1.20	0.6	1.8	10	22	30	1.2
Calif: Los Angeles.....	April	2.04	1.8	2.9	5	14	40	4.9
	May	1.88	2.1	2.6	5	23	45	5.6
	June	2.03	1.8	3.0	5	12	50	2.0
Colo: Denver.....	April	2.13	1.7	2.3	5	23	65	0.4
	May	2.07	1.7	2.7	5	33	60	2.1
	June	2.12	1.9	3.0	5	17	40	1.3
Del: Wilmington.....	April	2.11	1.3	3.4	5	19	55	0.6
	May	1.95	1.4	3.9	5	20	50	1.4
	June	1.96	1.4	3.3	5	22	50	5.2
Fla: Tampa.....	April	1.94	1.7	3.3	5	21	165	1.7
	May	1.55	0.9	2.0	5	14	85	5.6
	June	1.64	1.0	2.6	5	20	130	0.8
Hawaii: Honolulu.....	April	2.00	1.0	2.5	5	10	85	1.5
	May	2.08	0.8	3.5	5	10	60	0.8
	June	2.10	0.8	2.7	5	10	60	1.4
Idaho: Idaho Falls.....	April ^b	1.77	1.2	2.7	5	14	75	0.2
	May	1.90	2.3	2.8	5	48	55	1.0
	June ^b	1.47	1.0	2.1	5	9	45	0.8
Ill: Chicago.....	April	1.36	1.0	2.0	5	11	50	1.1
	May ^b	1.55	1.1	2.2	5	12	60	0.3
	June ^b	1.63	1.1	2.3	10	20	50	2.8
Ky: Louisville.....	April	1.26	1.1	2.1	5	16	30	1.5
	May	1.34	1.1	2.5	5	21	75	3.8
	June	1.31	1.3	2.4	15	25	40	1.5
La: New Orleans.....	April *	1.86	1.5	2.8	5	33	75	1.4
	May	2.35	1.9	3.8	5	49	80	1.2
	June	1.48	0.9	1.9	5	33	65	1.2
Mass: Boston.....	April	2.37	1.2	3.1	5	19	60	1.8
	May	2.56	1.5	3.8	5	18	90	1.2
	June	2.35	1.2	3.1	5	21	70	1.2
Mo: St. Louis.....	April	1.92	1.3	2.9	5	19	60	1.7
	May	2.40	1.9	3.6	5	29	70	0.5
	June ^b	2.47	2.0	4.0	75	42	85	1.1
Ohio: Cleveland.....	April	1.19	0.9	2.4	5	12	95	1.0
	May	1.50	0.9	2.4	5	10	60	1.2
	June	1.00	0.8	1.7	5	12	35	1.6
Pa: Pittsburgh.....	April ^b	2.30	1.4	3.2	5	23	80	2.3
	May ^b	2.31	1.4	2.8	5	21	90	1.7
	June ^b	2.43	1.5	3.4	5	37	40	2.0
S.C: Charleston.....	April	1.45	1.0	1.7	5	19	35	2.1
	May	1.86	1.1	2.8	5	22	45	1.3
	June	1.38	0.8	1.8	15	19	70	1.2
S. Dak: Sioux Falls.....	April	1.68	1.3	2.9	5	29	110	1.3
	May	1.70	1.4	2.6	5	24	70	1.3
	June	1.61	1.6	2.7	15	19	55	2.7
Tex: Austin.....	April	1.70	0.8	2.2	5	10	40	1.6
	May	1.65	1.0	2.0	5	10	35	1.7
	June	1.68	0.8	2.0	5	17	40	0.5
Vt: Burlington.....	April	1.22	0.7	2.0	5	13	60	0.8
	May	1.28	0.9	2.0	5	30	70	0.6
	June	1.19	0.7	1.8	5	15	50	0.9
Wash: Seattle.....	April ^b	1.43	1.1	2.3	5	29	95	0.4
	May ^b	1.50	1.2	2.6	5	27	80	2.1
	June ^b	1.63	1.3	2.3	5	45	80	1.8
Institutional average.....	April	1.72	1.2	2.4	5	16	65	1.8
	May	1.80	1.3	2.7	5	22	60	1.8
	June	1.66	1.2	2.4	5	18	65	1.8

* Data for this month were not used in computing the average for all institutions since food samples were collected from two or more children under 9 years of age.

^b Data for this month were not used in computing the average for all institutions since food samples were collected from two or more children over 12 years of age.

**2. Estimated daily intake of radionuclides in
California diets
January-April 1966**

*Bureau of Radiological Health
California State Department of Public Health*

Since January 1964, the Bureau of Radiological Health, California State Department of Public Health, has made estimates of radionuclide levels in the diets of Californians (6).

Recognizing that a standard or typical diet does not exist, because of variations in individual tastes, an effort was made to select a diet

which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the house diet of a hospital in each of the 20 geographic areas of interest (figure 2).

Hospitals were chosen as the source of diet samples under the hypothesis that their diets are as reasonably representative as any other. General hospitals exist in each of the 20 selected geographic areas and operate with trained dietitians. There is good reason to believe that hospitals utilize foods which are marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureau of Nutrition and Hospitals.



Figure 2. California diet sampling stations

Sampling procedure

In general, the sampling procedure is the same at each hospital. Samples are collected every 2 months at each facility. Each sample represents the edible portion of a regular meal (the standard diet) for a full 7-day week (21 consecutive meals).

Analytical procedures

After weighing at the Laboratory, each sample is homogenized and gamma-scanned, then dried and ashed prior to analysis for strontium-89, strontium-90, radium-226, and stable calcium, strontium, and sodium.

Table 3. Estimated daily intake of radionuclides in California diets, January-February 1966 *

City	Con- sumption (kg/ capita • day) ^b	Intake, pCi/capita • day						Intake, g/capita • day			
		Strontium- 90	Radium- 226	Cesium- 137	Zirconium- 95	Manga- nese-54	Cerium- 141/144	Potas- sium *	Sodium	Calcium	Stable strontium
Bakersfield	2.5	10	0.2	26	5	0	6	3.0	4.4	1.3	0.006
Berkeley	2.4	7	1.0	42	0	0	10	2.6	5.1	0.6	0.004
Bishop	2.0	9	1.0	32	0	1	22	2.8	4.0	1.2	0.003
Brawley	2.2	12	0.4	38	4	0	3	2.8	3.8	1.3	0.004
Crescent City	2.1	29	0.8	78	6	0	0	2.7	3.7	1.0	0.003
Eureka	2.5	16	0.6	52	3	0	3	3.2	2.4	1.8	0.003
Fresno	2.4	11	0.7	44	0	0	4	2.4	4.0	1.0	0.006
Los Angeles	2.2	13	0.7	38	5	0	0	2.8	5.2	1.0	0.005
Needles	2.1	11	0.7	40	1	0	5	3.0	4.3	1.0	0.009
Quincy	1.4	8	0.2	25	0	0	1	1.7	2.6	0.5	0.003
Redding	2.1	16	0.9	58	4	0	2	2.6	3.8	1.3	0.006
Sacramento	2.6	17	2.8	46	2	0	8	4.4	7.3	1.8	0.003
Salinas	2.3	7	0.7	51	2	0	0	3.0	5.7	0.8	0.002
San Bernardino	1.1	3	0.9	14	2	0	2	1.8	2.7	1.0	0.001
San Diego	2.0	3	0.5	54	0	0	0	2.6	3.1	0.9	0.003
San Luis Obispo	1.3	6	0.5	27	1	0	2	1.1	2.1	0.7	0.002
Santa Barbara	2.2	11	0.6	70	5	0	12	2.8	3.7	1.0	0.003
Santa Rosa	2.3	8	0.6	50	2	0	13	2.4	3.0	1.1	0.003
Susanville	1.5	6	0.4	33	3	0	7	1.8	3.2	0.6	0.001
Ukiah	2.5	13	0.4	52	13	27	0	3.0	4.0	1.4	0.006

* Based on analyses of Hospital Standard Diets located in listed cities. Strontium-89 not detectable.

^b Kilograms of food per person per day in this diet.

* National potassium contains 0.0119 percent radioactive potassium-40.

Table 4. Estimated daily intake of radionuclides in California diets, March-April 1966 *

City	Con- sumption (kg/ capita • day) ^b	Intake, pCi/capita • day						Intake, g/capita • day			
		Strontium- 90	Radium- 226	Cesium- 137	Zirconium- 95	Manga- nese-54	Cerium- 141/144	Potas- sium *	Sodium	Calcium	Stable strontium
Bakersfield	1.6	11	0.1	11	0	0	0	3.3	6.4	0.9	0.004
Berkeley	2.3	12	0.8	41	3	0	5	3.4	3.8	1.3	0.002
Bishop	1.9	8	0.6	29	0	0	0	1.9	3.4	0.8	0.002
Brawley	1.9	11	0.6	25	2	0	0	2.5	3.4	0.9	0.003
Crescent City	2.1	18	0.3	49	2	0	0	2.2	4.0	0.9	0.001
Eureka	1.9	10	0.7	26	3	0	16	2.0	3.3	0.7	0.002
Fresno	1.5	13	0.6	38	0	0	4	1.9	2.4	0.7	0.001
Los Angeles	2.0	8	1.4	46	5	0	3	2.5	3.8	1.0	0.003
Needles	1.8	9	0.5	24	1	0	0	2.3	3.4	0.8	0.002
Quincy	1.4	9	0.5	23	1	0	6	1.7	2.7	0.5	0.002
Redding	2.4	13	1.0	40	3	0	3	2.2	4.4	1.0	0.001
Sacramento	2.2	10	1.2	27	0	0	0	2.1	3.7	0.9	0.002
Salinas	2.5	8	0.9	32	0	0	0	3.0	5.4	1.0	0.002
San Bernardino	1.8	7	0.5	17	2	0	15	2.2	3.3	0.8	0.002
San Diego	1.8	8	0.3	23	0	0	12	2.4	2.9	0.3	0.003
San Luis Obispo	1.3	10	0.8	22	0	0	0	1.8	3.4	1.0	0.003
Santa Barbara	2.1	14	0.5	27	1	0	0	2.5	3.6	1.1	0.003
Santa Rosa	2.1	11	0.7	32	2	0	0	1.8	2.4	1.1	0.002
Susanville	1.9	9	0.8	38	1	0	0	2.1	3.9	0.6	0.002
Ukiah	2.2	10	0.6	61	0	0	3	2.4	2.6	0.9	<0.001

* Based on analyses of Hospital Standard Diets located in listed cities. Strontium-89 not detectable.

^b Kilograms of food per person per day in this diet.

* National potassium contains 0.0119 percent radioactive potassium-40.

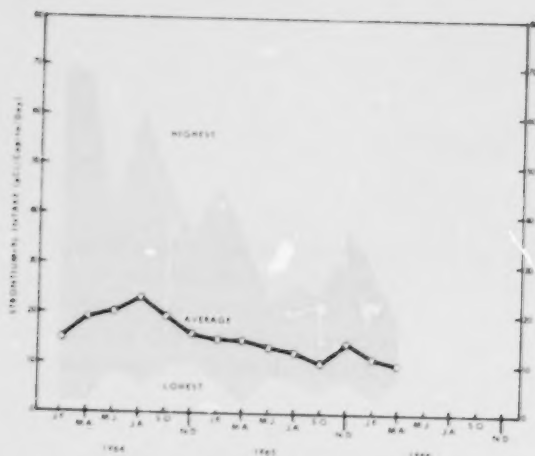


Figure 3. Averages and ranges of daily strontium-90 intake in California diets

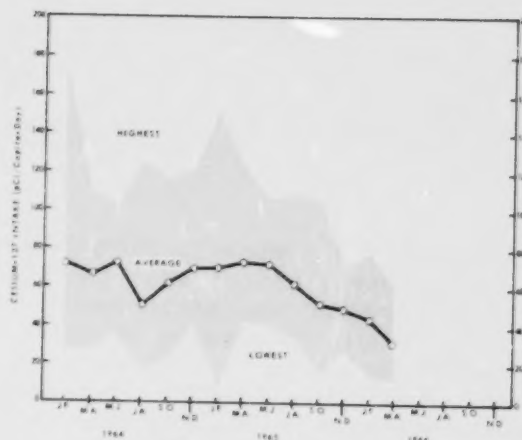


Figure 4. Averages and ranges of daily cesium-137 intake in California diets

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory of the California State Department of Public Health. Accompanying each sample is a record prepared by the dietitians indicating the types and quantities of food included.

Data and discussion

The resultant estimates of daily intake of radionuclides in the California diets are given in table 3 (January–February 1966) and table 4 (March–April 1966).

It should be noted that levels of radioactivity were observed to be far below those levels for which consideration should be given to protective health action. Strontium-90 intake in the California diet for the January–February 1966 period varied from 3 to 29 pCi/capita · day, with an average of 11 pCi/capita · day. Cesium-137 intake varied from 14 to 78 pCi/capita · day with an average of 44 pCi/capita · day. For the March–April 1966 sampling period, the strontium-90 intake varied from 7 to 18 pCi/capita · day, with an average of 10 pCi/capita · day. Cesium-137 intake varied from 11 to 61 pCi/capita · day, with an average of 32 pCi/capita · day. A summary of strontium-90 and cesium-137 intake trends in California diets

from January 1964 through April 1966 is given in figures 3 and 4.

Previous coverage in Radiological Health Data and Reports:

Period	Issue
January–June 1964	March and April 1965
July–October 1964	September 1965
November–December 1964	December 1965
January–April 1965	March 1966
May–August 1965	June 1966
September–December 1965	September 1966

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- (4) GRUNDY, R. D., C. CALVERT, and A. G. BERGER. Summary of results of Institutional Total Diet Sampling Network, 1961–1964. *Radiol Health Data* 6:691–698 (December 1965).
- (5) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402 (September 1961).
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Section II. Water

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (1). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (2-4), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter

and 10 pCi/liter, respectively. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the guides recommended by FRC for control action. In the known absence¹ of strontium-90 and alpha emitters, the limit is 1,000 pCi/liter gross beta activity, except when more complete analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water programs previously reported in *Radiological Health Data and Reports* are listed below.

¹ Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium-90, respectively.

Program	Period reported	Last presented
California Water Sampling Program	July-December 1965	November 1966
Coast Guard Water Sampling Program	1965	November 1966
Colorado River Basin Sampling Network	1962-1964	November 1965
Drinking Water Analysis Program	1962	October 1965
Florida Water Sampling Program	1964	November 1965
Kentucky Water Sampling Program	May 1963-June 1964	March 1965
Lower Columbia River Radiological Survey in Oregon	August 1963-July 1964	October 1965
Minnesota Surface Water Sampling Program	July-December 1965	July 1966
New York Surface Water Sampling Program	June-December 1965	June 1966
North Carolina Water Sampling Program	1964	November 1965
Radiostromtium in Tap Water, HASL	May and July-November 1965	June 1966
Washington Surface Water Sampling Program	July 1964-June 1965	May 1966

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GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, JULY 1966

*Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of Interior*

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as a part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha and beta analysis. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by

treatment processes. Strontium-90 results are reported quarterly. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the June 1966 issue of Radiological Health Data and Reports.



Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, July 1966

Complete data and exact sampling locations are published in annual compilations (1-6) and are available on request.

Special note is made when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radio-

activity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During both June and July, the following stations showed alpha radioactivity in excess of 15 pCi/liter on dissolved solids:

South Platte River: Julesburg, Colo.
Arkansas River: Coolidge Kans.

Table 1. Radioactivity in raw surface waters, July 1966

Station	Average beta activity (pCi/liter)			Average alpha activity (pCi/liter)			Station	Average beta activity (pCi/liter)			Average alpha activity (pCi/liter)		
	Sus-pended	Dis-solved	Total	Sus-pended	Dis-solved	Total		Sus-pended	Dis-solved	Total	Sus-pended	Dis-solved	Total
Animas River:							Missouri River:						
Cedar Hill, N. Mex.	1	6	7	0	1	1	Williston, N. Dak.	6	12	18	2	2	4
Arkansas River:							Bismarck, N. Dak.	1	13	14	0	2	2
Coolidge, Kans.	29	31	60	6	15	21	St. Joseph, Mo.	17	19	36	6	3	9
Ponca City, Okla.	1	9	10	0	2	2	North Platte River:						
Achafalaya River:							Henry, Nebr.	8	27	35	2	12	14
Morgan City, La.	2	10	12	<1	1	1	Ohio River:						
Bear River:							Toronto, Ohio.	5	10	15	1	0	1
Preston, Idaho.	2	20	22	0	6	6	Cairo, Ill.	1	5	6	0	1	1
Big Horn River:							Pend Oreille River:						
Hardin, Mont.	3	16	19	1	7	8	Albeni Falls Dam,						
Clearwater River:							Idaho.	<1	3	3	0	<1	<1
Lewiston, Idaho.	1	3	4	0	0	0	Platte River:						
Clinch River:							Plattsmouth, Nebr.	31	21	52	7	4	11
Clinton, Tenn.	0	4	4	0	0	0	Potomac River:						
Kingston, Tenn.*	16	17	33	<1	0	<1	Washington, D.C.	0	5	5	0	0	0
Colorado River:							Rainy River:						
Loma, Colo.	15	15	30	5	9	14	Baudette, Minn.	3	9	12	<1	0	<1
Paseo, Ariz.	0	20	20	0	5	5	Red River, North:						
Parker Dam, Calif.							Grand Forks,						
Ariz.	0	16	16	0	5	5	N. Dak.	1	22	23	0	2	2
Columbia River:							Red River, South:						
Wenatchee, Wash.	0	4	4	0	0	0	Alexandria, La.	3	12	15	1	0	1
Paseo, Wash.*	22	31	53	1	<1	1	Rio Grande:						
Clatskanie, Ore.	0	5	5	0	0	0	El Paso, Tex.	20	12	32	8	2	10
Connecticut River:							Laredo, Tex.	206	19	225	57	4	61
Enfield Dam, Conn.	0	4	4	0	0	0	San Joaquin River:						
Cumberland River:							Vernalis, Calif.	6	8	14	2	3	5
Cheatham Lock,							San Juan River:						
Tenn.	1	3	4	0	0	0	Shiprock, N. Mex.	0	6	6	2	12	14
Delaware River:							Savannah River:						
Philadelphia, Pa.	1	5	6	0	0	0	Port Wentworth,						
Great Lakes:							Ga.*	4	12	16	<1	0	<1
Duluth, Minn.	0	4	4	0	0	0	Snake River:						
Green River:							Payette, Idaho.	3	11	14	1	5	6
Dutch John, Utah.	1	16	17	0	2	2	Wawawai, Wash.	0	6	6	0	1	1
Hudson River:							Ice Harbor Dam,						
Poughkeepsie, N.Y.	2	6	8	0	0	0	Wash.	1	2	3	0	1	1
Illinois River:							South Platte River:						
Peoria, Ill.	2	16	18	0	2	2	Julesburg, Colo.	11	56	67	2	30	32
Grafton, Ill.	2	16	18	0	3	3	Wabash River:						
Kansas River:							New Harmony, Ind.	0	7	7	0	1	1
DeSoto, Kans.	4	18	22	1	2	3	Yellowstone River:						
Klamath River:							Sidney, Mont.	66	6	72	19	2	21
Keno, Ore.	1	12	13	<1	0	<1	Maximum	206	56	225	57	30	61
Maumee River:							Minimum	0	2	3	0	0	0
Toledo, Ohio.	1	11	12	1	2	3							
Mississippi River:													
St. Paul, Minn.	2	16	18	0	3	3							
E. St. Louis, Ill.	4	12	16	2	2	4							
New Roads, La.	15	11	26	4	2	6							
New Orleans, La.	5	14	19	4	3	7							

* Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility, in addition to the contribution from fallout and naturally occurring radionuclides common to all stations.

The following stations dropped below 15 pCi/liter of alpha radioactivity on either suspended or dissolved solids:

Atchafalaya River: Morgan City, La.
North Platte River: Henry, Nebr.

The following stations showed an increase in alpha radioactivity to values of more than 15 pCi/liter on suspended solids:

Platte River: Plattsmouth, Nebr.
Rio Grande: Laredo, Tex.
Yellowstone River: Sidney, Mont.

The high alpha and beta radioactivity for Laredo, Tex., was entirely due to high turbidity in the sample collected on July 5, 1966. The remaining samples for that month showed only low levels of radioactivity.

During July the beta radioactivity at Pasco, Wash., on the Columbia River showed unusually low values. This was a result of reactor shutdown.

REFERENCES

- (1) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
- (2) *Ibid.*, 1959 Edition.
- (3) *Ibid.*, 1960 Edition.
- (4) *Ibid.*, 1961 Edition.
- (5) *Ibid.*, 1962 Edition.
- (6) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

RADIOACTIVITY IN MINNESOTA MUNICIPAL WATER SUPPLIES JANUARY-JUNE 1966¹

*Division of Environmental Sanitation
Minnesota Department of Health*

The analysis of various Minnesota waters for radioactivity concentration was initiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies in the State, as well as selected lakes throughout the State.

¹ Data and information from "Survey of Environmental Radioactivity, January-June 1966." State of Minnesota Department of Public Health, University Campus, Minneapolis, Minn. 55440. Publication No. C00-651-33.

As many as 25 surface streams and lakes involving 74 stations have been sampled. At present, nine surface streams and lakes used as municipal water supplies are sampled routinely (figure 1). Grab samples of raw and treated water are collected weekly at Hallock, East Grand Forks, Eveleth, Fairmont, and St. Paul; and monthly at Crookston, International Falls, and St. Cloud. Minneapolis tap water is analyzed weekly. No raw water is collected from the Minneapolis supply.

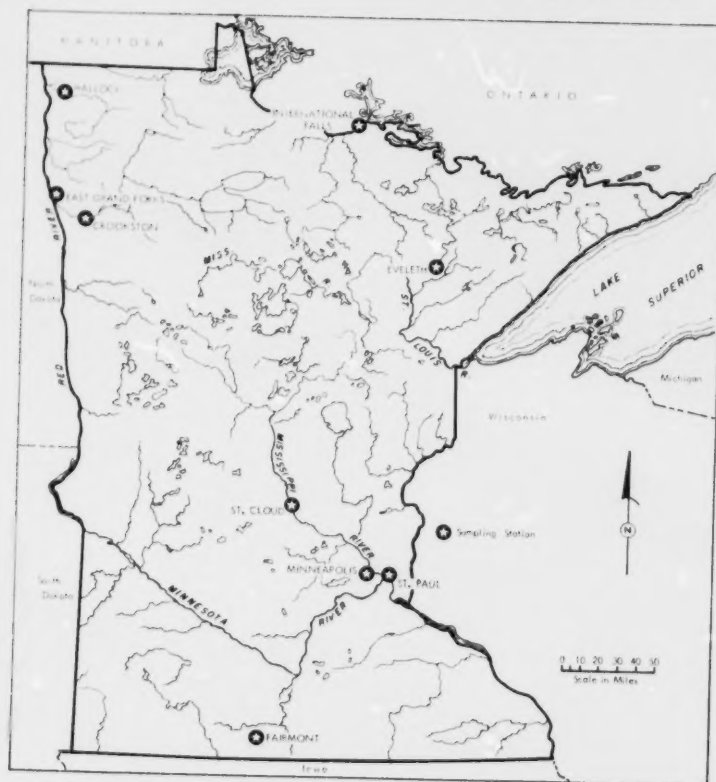


Figure 1. Minnesota surface water sampling locations

The samples are forwarded to the Division's laboratory, where they are analyzed for gross beta activity. A 250-ml sample of water is transferred to a 2-inch planchet and evaporated at 75°C. The solid residue (suspended-plus-dissolved solids) is fixed by adding lucite in acetone. The sample is then counted for beta activity in an internal-proportional counter. Counter standardization is accomplished by adding known amounts of thallium-204 standard to solutions containing the normal range of solids.

Table 1 shows a summary of the monthly average gross beta activity in Minnesota municipal water supplies from January through June 1966. In averaging, samples reported to contain nondetectable concentrations were assigned an arbitrary concentration of 7 pCi/liter.

The data obtained on gross beta activity in Minnesota surface waters show a variation of concentrations, with no readily apparent trends.

Variations in precipitation and flow rates of streams could contribute to this fluctuation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from 4 to 96 pCi/liter, which is well below the Public Health Service Drinking Water Standards (1). Treated water in most cases contained less beta activity than the corresponding raw water.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
December 1962-June 1963	November 1963
July-December 1963	June 1964
January-June 1964	January 1965
July-December 1964	August 1965
January-June 1965	February 1966
July-December 1965	July 1966

REFERENCE

- (1) PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

Table 1. Total beta concentrations in Minnesota raw and treated water supplies January-June 1966

Town and water source	Type of water	Average concentrations, pCi/liter					
		Jan	Feb	Mar	Apr	May	June
Crookston, Red Lake River.....	Raw.....	19	96	33	21	17	23
	Treated.....	37	7	23	15	21	26
East Grand Forks, Red Lake River.....	Raw.....	28	25	18	15	20	23
	Treated.....	14	10	10	10	13	12
Eveleth, St. Mary's Lake.....	Raw.....	38	16	16	19	11	13
	Treated.....	20	13	14	14	14	14
Fairmont, Budd Lake.....	Raw.....	26	23	14	5	4	20
	Treated.....	10	7	8	6	6	8
Hallock, Two Rivers South Fork.....	Raw.....	51	31	22	18	24	29
	Treated.....	7	11	10	10	9	11
International Falls, Rainy River.....	Raw.....	7	7	11	11	9	10
	Treated.....	17	19	10	10	9	9
Minneapolis Tap Water.....	Raw.....	11	8	11	6	7	7
	Treated.....	11	8	11	6	7	7
St. Cloud, Mississippi River.....	Raw.....	7	30	13	14	13	15
	Treated.....	17	7	9	7	4	6
St. Paul, Vadnais Chain of Lakes.....	Raw.....	24	16	15	14	14	17
	Treated.....	14	8	9	12	8	8

Section III. Air and Deposition

RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of

atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson (1) in 1962. In addition to the programs presented in this issue, the following program was previously covered in *Radiological Health Data and Reports*:

<u>Network</u>	<u>Period</u>	<u>Issue</u>
HASL Fallout Network	July-December 1965	September 1966

1. Radiation Surveillance Network September 1966

National Center for Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN), which regularly gathers samples at 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Maryland, for laboratory analysis. The alerting function of the network is provided by

routine field estimates of the gross beta activity made by the station operators prior to submission of the samples for laboratory analysis. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (2). A detailed description of the sampling and analytical procedures was presented in the November 1966 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air and deposition by precipitation during September 1966. Time profiles of gross beta radioactivity in air for eight RSN stations are shown in figure 2. Gamma-ray spectroscopy was performed on 307 air samples. No fresh fission products were identified.



Figure 1. Radiation Surveillance Network sampling stations

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Table 1. Gross beta activity in surface air and precipitation, September 1966

Station location		Number of samples		Air surveillance gross beta activity, pCi/m ³			Last profile in RHD&R	Precipitation	
		Air	Pptn	Maximum	Minimum	Average *		Total depth (mm)	Total deposition (nCi/m ²)
Ala:	Montgomery	28	5	0.20	<0.10	<0.11	Nov 66	63	<13
Alaska:	Adak	30		<0.10	<0.10	<0.10	June 66	(b)	
	Anchorage	18	8	<0.10	<0.10	<0.10	Dec 66	54	<11
	Attu Island	30		<0.10	<0.10	<0.10	July 66	(b)	
	Fairbanks	16	1	<0.10	<0.10	<0.10	Apr 66	1	<1
	Juneau	19	19	<0.10	<0.10	<0.10	Jul 65	591	<118
	Kodiak	3		<0.10	<0.10	<0.10	May 66	(b)	
	Nome	18		<0.10	<0.10	<0.10	Sept 66	(b)	
	Pt. Barrow	14		<0.10	<0.10	<0.10	Aug 66	(b)	
	St. Paul Island	30		<0.10	<0.10	<0.10	Oct 66	(b)	
Ariz:	Phoenix	24		0.23	<0.10	<0.11	July 65	(b)	
Ark:	Little Rock	27	2	<0.10	<0.10	<0.10	Dec 66	14	<3
Calif:	Berkeley	20	1	<0.10	<0.10	<0.10	May 66	3	<1
	Los Angeles	19	2	<0.10	<0.10	<0.10	Sept 66	7	<1
	San Diego	17		<0.10	<0.10	<0.10	May 66	(b)	
C.Z:	Aneón	30	4	<0.10	<0.10	<0.10	May 66	42	<8
Colo:	Denver	30	6	<0.10	<0.10	<0.10	Jan 67	98	<20
Conn:	Hartford	21		<0.10	<0.10	<0.10	Nov 66	(b)	
Del:	Dover	22	7	<0.10	<0.10	<0.10	Aug 66	178	<36
D.C:	Washington	27	13	<0.10	<0.10	<0.10	Dec 66	173	<35
Fla:	Jacksonville	28	13	<0.10	<0.10	<0.10	Jan 67	233	<47
	Miami								
Ga:	Atlanta	(*)	8				Oct 66	66	<13
Guam:	Agaña	30		<0.10	<0.10	<0.10	Nov 66	(b)	
Hawaii:	Honolulu	30		<0.10	<0.10	<0.10	July 66	(b)	
Idaho:	Boise	29		<0.10	<0.10	<0.10	July 66	(b)	
Ill:	Springfield	30	6	0.13	<0.10	<0.10	Aug 66	101	<20
Ind:	Indianapolis	30	9	0.11	<0.10	<0.10	Oct 66	148	<30
Iowa:	Iowa City	26	2	<0.10	<0.10	<0.10	May 66	9	<2
Kans:	Topeka	30	5	<0.10	<0.10	<0.10	Dec 66	27	<6
Ky:	Frankfort	28	7	<0.10	<0.10	<0.10	Aug 66	44	<9
La:	New Orleans	30	10	<0.10	<0.10	<0.10	Aug 66	205	<41
Maine:	Augusta	30	6	<0.10	<0.10	<0.10	Sept 66	96	<19
	Presque Isle	24	7	<0.10	<0.10	<0.10	May 66	71	<14
Md:	Baltimore	20	8	<0.10	<0.10	<0.10	Jan 67	71	<14
	Rockville	15		<0.10	<0.10	<0.10	July 66	(b)	
Mass:	Lawrence	29	8	<0.10	<0.10	<0.10	Nov 66	145	<29
	Winchester	29	8	<0.10	<0.10	<0.10	June 66	80	<16
Mich:	Lansing	30	7	<0.10	<0.10	<0.10	July 66	32	<7
Minn:	Minneapolis	21	4	<0.10	<0.10	<0.10	Nov 66	60	<12
Miss:	Jackson	29	7	<0.10	<0.10	<0.10	Sept 66	65	<19
Mo:	Jefferson City	30	6	<0.10	<0.10	<0.10	Oct 66	25	<5
Mont:	Helena	30	4	<0.10	<0.10	<0.10	June 66	8	<2
Nebr:	Lincoln	15	6	0.35	<0.10	<0.13	Oct 66	102	<21
Nev:	Las Vegas	22		0.13	<0.10	<0.10	Apr 66	(b)	
N.H:	Concord	18		<0.10	<0.10	<0.10	Aug 66	(b)	
N.J:	Trenton	29	9	<0.10	<0.10	<0.10	Sept 66	51	<10
N. Mex:	Santa Fe	28	5	<0.10	<0.10	<0.10	June 66	16	<3
N.Y:	Albany	20	7	<0.10	<0.10	<0.10	Oct 66	71	<14
	Buffalo	27		<0.10	<0.10	<0.10	May 66	(b)	
	New York	29		<0.10	<0.10	<0.10	June 66	(b)	
N.C:	Gastonia	30	7	<0.10	<0.10	<0.10	May 66	101	<20
N. Dak:	Bismarck	29	4	0.11	<0.10	<0.10	Aug 66	19	<4
Ohio:	Cincinnati	21		<0.10	<0.10	<0.10	Nov 66	(b)	
	Columbus	29	6	0.12	<0.10	<0.10	Sept 66	106	<21
	Painesville	27	7	<0.10	<0.10	<0.10	Jan 67	75	<15
Okla:	Oklahoma City	27	7	<0.10	<0.10	<0.10	July 66	56	<11
	Ponca City	28	8	<0.10	<0.10	<0.10	Jan 67	111	<22
Ore:	Portland	30	8	<0.10	<0.10	<0.10	Oct 66	37	<7
Pa:	Harrisburg	29	2	<0.10	<0.10	<0.10	Oct 66	41	<9
P.R:	San Juan	24	8	<0.10	<0.10	<0.10	Sept 66	216	<43
R.I:	Providence	28	6	<0.10	<0.10	<0.10	July 66	126	<25
S.C:	Columbia	27	5	<0.10	<0.10	<0.10	June 66	43	<9
S. Dak:	Pierre	29	7	<0.10	<0.10	<0.10	July 65	34	<7
Tenn:	Nashville	29	10	<0.10	<0.10	<0.10	July 66	77	<15
Tex:	Austin	29	5	<0.10	<0.10	<0.10	Nov 66	102	<20
	El Paso	29	5	<0.10	<0.10	<0.10	Aug 66	42	<9
Utah:	Salt Lake City	30	5	0.13	<0.10	<0.10	Sept 66	22	<4
Vt:	Barre	27	8	<0.10	<0.10	<0.10	Dec 66	83	<17
Va:	Richmond	30	7	<0.10	<0.10	<0.10	Dec 66	123	<25
Wash:	Seattle	30	4	<0.10	<0.10	<0.10	Dec 66	33	<7
	Spokane	30	2	<0.10	<0.10	<0.10	Nov 66	15	<3
W. Va:	Charleston	30	10	<0.10	<0.10	<0.10	June 66	76	<15
Wis:	Madison	29	3	<0.10	<0.10	<0.10	Dec 66	19	<4
Wyo:	Cheyenne	28	6	<0.10	<0.10	<0.10	Apr 66	36	<7
Network summary		1,889	360	0.35	<0.10	<0.10		82	<16

* The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If 10 percent or more samples from a station contain <0.10 pCi/m³, a less-than sign is placed before the average.

† No precipitation sample collected.

* No report received.

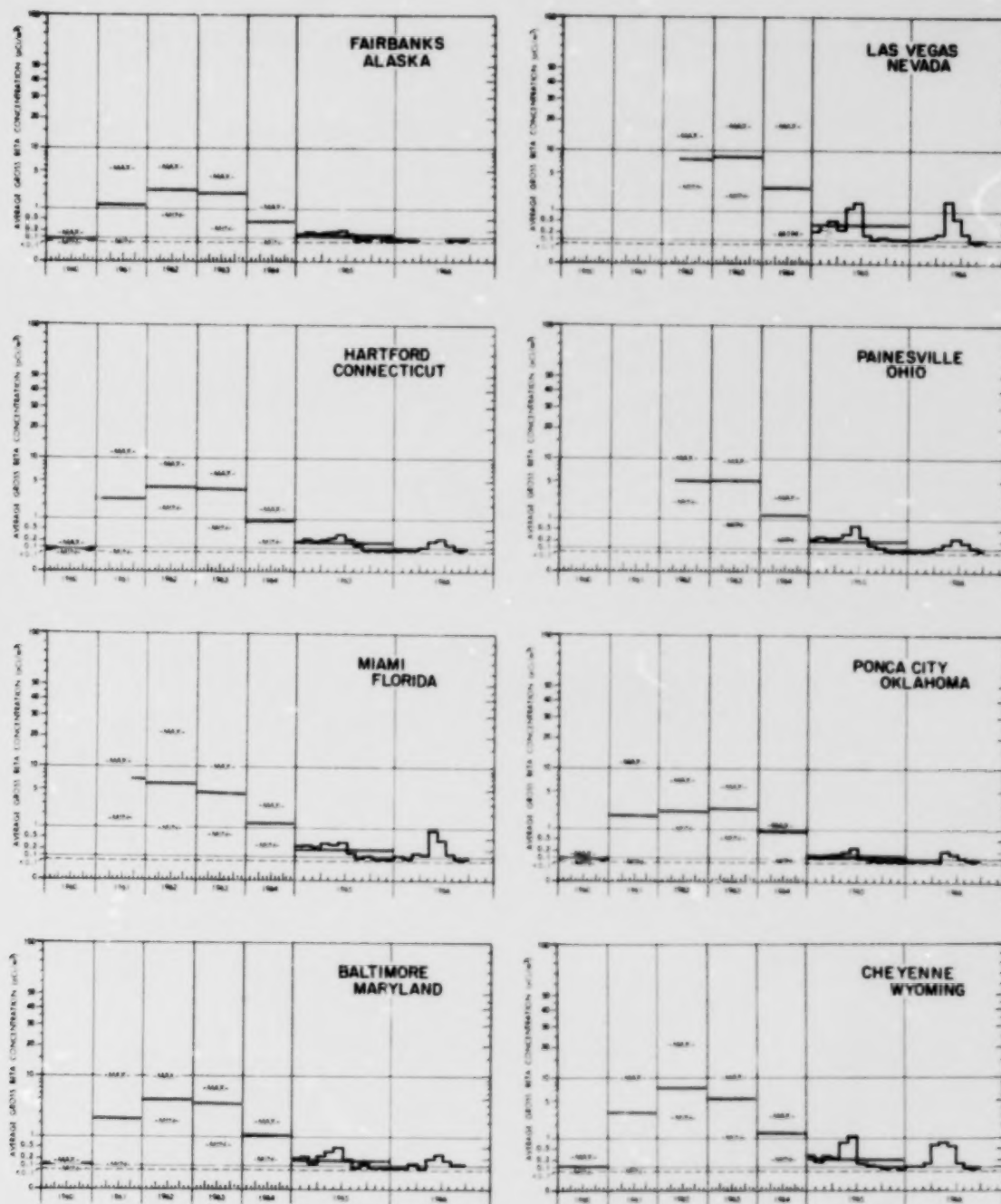


Figure 2. Monthly and yearly profiles of beta activity in air—Radiation Surveillance Network, 1960–September 1966

2. Canadian Air and Precipitation Monitoring Program, September 1966¹

Radiation Protection Division Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (3-7).

A summary of the sampling procedures and methods of analysis was presented in the November 1966 issue of *Radiological Health Data and Reports*.

¹ Prepared from information and data in the October 1966 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for September 1966 are presented in table 2.

Table 2. Canadian gross beta activity in surface air and precipitation, September 1966

Station	Number of samples	Air surveillance activity (pCi/m ³)			Precipitation measurements	
		Max-imum	Min-imum	Average	Average concentrations (pCi/liter)	Total deposition nCi/m ²
Calgary	30	0.1	0.0	0.1	121	0.6
Coral Harbour	29	0.1	0.0	0.0	18	1.1
Edmonton	30	0.1	0.0	0.1	10	1.2
Ft. Churchill	30	0.1	0.0	0.0	31	1.3
Ft. William	29	0.1	0.0	0.1	9	0.3
Fredericton	30	0.1	0.0	0.0	10	1.0
Goose Bay	30	0.1	0.0	0.0	5	0.2
Halifax	29	0.1	0.0	0.1	10	0.9
Inuvik	30	0.1	0.0	0.0	15	0.6
Montreal	30	0.1	0.0	0.1	13	1.1
Moosonee	29	0.1	0.0	0.0	7	1.0
Ottawa	30	0.1	0.0	0.1	9	0.5
Quebec	21	0.1	0.0	0.0	10	1.6
Regina	30	0.1	0.0	0.1	48	0.6
Resolute	28	0.1	0.0	0.0	31	0.6
St. John's, Nfld.	30	0.1	0.0	0.0	11	0.7
Saskatoon	30	0.1	0.0	0.1	67	0.9
Sault Ste. Marie	30	0.1	0.0	0.1	17	1.3
Toronto	30	0.1	0.0	0.1	21	1.3
Vancouver	30	0.1	0.0	0.0	26	1.8
Whitehorse	30	0.1	0.0	0.0	10	0.4
Windsor	30	0.1	0.0	0.1	20	0.6
Winnipeg	30	0.2	0.0	0.1	57	1.0
Yellowknife	29	0.1	0.0	0.0	48	1.2
Network summary		0.1	0.0	0.1	28	0.9



Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program September 1966

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F., Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the

University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day, using high-volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta activity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of eight samples per month was needed to get a reliable average activity at each station (8).

The maximum, minimum, and average fission product beta concentrations in surface air during September 1966 are presented in table 3.



Figure 4. Mexican air sampling locations

Table 3. Mexican gross beta activity of airborne particulates, September 1966

Station	Number of samples	Gross beta activity, pCi/m ³		
		Maximum	Minimum	Average
Acapulco.....	9	<0.1	<0.1	<0.1
Chihuahua.....	7	<0.1	<0.1	<0.1
Ciudad Juárez.....	15	<0.1	<0.1	<0.1
Ensenada.....	2	0.1	0.1	0.1
Guadalajara.....	2	<0.1	<0.1	<0.1
Guaymas.....	5	<0.1	<0.1	<0.1
La Paz.....	16	<0.1	<0.1	<0.1
Matamoros.....	11	<0.1	<0.1	<0.1
Manatán.....	9	0.1	<0.1	<0.1
Mérida.....	15	<0.1	<0.1	<0.1
México, D. F.....	3	<0.1	<0.1	<0.1
Nuevo Laredo.....	NS	NS	NS	NS
San Luis Potosí.....	15	<0.1	<0.1	<0.1
Tampico.....	12	0.1	<0.1	<0.1
Torreón.....	13	<0.1	<0.1	<0.1
Veracruz.....	15	<0.1	<0.1	<0.1

NS, no sample collected; station temporarily shut down.

1. Pan American Air Sampling Program September 1966

Pan American Health Organization and U.S. Public Health Service

Gross beta activity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the National Center for Radiological Health, PHS, and are identical with those employed for



Figure 5. Pan American Air Sampling Program stations

the Radiation Surveillance Network. The air-sampling station positions are shown in figure 5.

The September 1966 air-monitoring results from the participating countries are given in table 4. Levels were generally lower than

5. National Air Sampling Network July-September 1966

National Center for Air Pollution Control
Public Health Service

Table 4. PAHO gross beta activity in surface air
September 1966

Station location	Number of samples	Gross beta activity (pCi/m ³)		
		Maximum	Minimum	Average*
Argentina: Buenos Aires.....	22	10.97	<0.10	<0.49
Chile: Santiago.....	27	2.11	<0.10	<0.22
Colombia: Bogota.....	24	<0.10	<0.10	<0.10
Ecuador: Guayaquil.....	29	0.30	<0.10	<0.11
Jamaica: Kingston.....	23	<0.10	<0.10	<0.10
Peru: Lima.....	16	0.48	<0.10	<0.24
Venezuela: Caracas.....	1	<0.10	<0.10	<0.10
West Indies: Trinidad.....	21	0.11	<0.10	<0.10
Pan American summary.....	163	10.97	<0.10	<0.18

* The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If 10 percent or more of the samples from a station contain <0.10 pCi/m³, a less-than sign is placed before the average.

August levels until the last 3 days of the month, when an abrupt rise in activity occurred in samples from Buenos Aires, Argentina, and Santiago, Chile. Concentrations of fresh fission products are identified in the samples in table 5. The decay index of the September 30, 1966, Buenos Aires sample indicates that the majority of the activity was probably from the French nuclear test on September 24, 1966. The other samples were not active enough for reliable "age" estimates.

Table 5. Fresh fission products in PAHO air samples
September 1966

Location	Date	Concentration (pCi/m ³)
Chile: Santiago.....	September 28	0.40
	September 29	2.11
Argentina: Buenos Aires....	September 29	0.87
	September 30	10.97

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. The NASN analyzes air samples for the total quantity of suspended particulate matter, benzene-soluble organic matter, and gross beta radioactivity. Selected samples are also analyzed for nitrates, sulfates, and a number of metals. The resulting data aid in the detection of trends in levels of pollution with respect to time, location, population density, climate, and other factors.

Gross beta activity in air

NASN stations (figure 6) are manned by co-operating Federal, State, and local agencies. The current basic network consists of 110 sampling stations which operate every year in 73 large cities and 37 non-urban areas. In addition, there are stations in 130 cities which operate every other year. Thus, the NASN consists of 240 sampling stations, 175 of which are active in any given year.

Continuous 24-hour samples of suspended particulate matter are taken at each station. The samples, representing approximately 2,000 cubic meters of air, are collected on glass-fiber filters on a biweekly random sampling schedule. They are sent for analysis to the Network laboratory at the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio. July through September 1966 gross beta activities in air are given in table 6.

Table 6. NASN fission product gross beta activity in surface air, July-September 1966

Station	Number of samples	Concentration, pCi/m ³			Station	Number of samples	Concentration, pCi/m ³		
		Maximum	Minimum	Average			Maximum	Minimum	Average
Ala: Birmingham	6	0.2	0.1	0.1	Nev: Las Vegas	7	0.4	0.1	0.2
Alaska: Gadsden	7	0.2	<0.1	0.1	N.H.: White Pine County *	7	0.2	0.1	0.1
Alaska: Mobile	7	0.2	<0.1	0.1	N.H.: Concord	7	0.3	0.1	0.2
Aris: Anchorage	5	0.2	<0.1	0.1	N.J.: Coos County *	7	0.2	0.1	0.2
Aris: Grand Canyon Park *	7	0.3	0.1	0.2	N.J.: Marlton	7	0.3	0.1	0.2
Aris: Paradise Valley	7	0.3	0.1	0.1	N.J.: Camden	7	0.3	0.1	0.2
Aris: Phoenix	5	0.2	0.1	0.1	N.J.: Glassboro	7	0.3	0.1	0.2
Aris: Tucson	7	0.3	<0.1	0.1	N.J.: Jersey City	6	0.2	0.1	0.2
Ark: Little Rock	7	0.2	0.1	0.2	N.J.: Newark	7	0.3	<0.1	0.1
Ark: Montgomery County *	6	0.2	0.1	0.1	N.J.: Perth Amboy	7	0.4	0.1	0.2
Ark: Texarkana	6	0.1	0.1	0.1	N.J.: Trenton	5	0.2	0.1	0.1
Ark: West Memphis	7	0.2	0.1	0.1	N. Mex.: Albuquerque	7	0.3	0.1	0.1
Calif: Burbank	7	0.2	0.1	0.1	N. Mex.: Rio Arriba County *	5	0.1	0.1	0.1
Calif: Humboldt County *	5	0.1	<0.1	0.1	N.Y.: Cape Vincent *	7	0.2	0.1	0.1
Calif: Los Angeles	7	0.2	0.1	0.1	N.C.: New York	7	0.3	0.1	0.1
Calif: Oakland	5	0.1	0.1	0.1	N.C.: Charlotte	7	0.4	0.1	0.2
Calif: Pasadena	6	0.2	0.1	0.1	N.C.: Cape Hatteras *	7	0.3	<0.1	0.1
Calif: San Diego	7	0.2	<0.1	0.1	Ohio: Akron	6	0.4	0.1	0.2
Calif: San Francisco	7	0.1	<0.1	0.1	Ohio: Cincinnati	7	0.3	0.1	0.2
Colo: Denver	7	0.3	0.1	0.1	Ohio: Cleveland	7	0.3	0.1	0.2
Conn: Montezuma County *	7	0.3	0.1	0.1	Ohio: Columbus	7	0.3	0.1	0.2
Conn: Hartford	7	0.3	0.1	0.1	Ohio: Dayton	7	0.3	0.1	0.2
Conn: New Haven	7	0.3	0.1	0.2	Ohio: Toledo	7	0.4	0.1	0.2
Del: Kent County *	7	0.3	<0.1	0.2	Ohio: Youngstown	7	0.3	0.1	0.2
Del: Newark	7	0.4	0.1	0.2	Okl.: Cherokee County *	7	0.3	0.1	0.2
Del: Wilmington	7	0.2	<0.1	0.1	Okl.: Oklahoma City	7	0.3	0.1	0.2
D.C.: Washington	5	0.3	0.1	0.2	Ore: Tulsa	7	0.3	0.1	0.1
Ga: Atlanta	7	0.2	<0.1	0.1	Ore: Curry County *	7	0.1	<0.1	<0.1
Hawaii: Honolulu	7	0.2	<0.1	0.1	Ore: Portland	5	0.1	0.1	0.1
Idaho: Boise	7	0.4	0.1	0.2	Pa: Clarion County *	7	0.3	0.1	0.1
Idaho: Butte County *	7	0.4	0.1	0.2	Pa: Lancaster	7	0.4	0.1	0.2
Ill: Chicago	7	0.3	0.1	0.2	Pa: Philadelphia	6	0.3	<0.1	0.2
Ind: East Chicago	7	0.3	0.1	0.2	Pa: Pittsburgh	7	0.2	0.1	0.1
Ind: Hammond	7	0.3	0.1	0.2	Pa: Reading	7	0.2	<0.1	0.1
Ind: Indianapolis	7	0.4	0.1	0.2	Pa: Warminster	7	0.3	0.1	0.2
Ind: N. Monroe State Forest	6	0.3	<0.1	0.2	Pa: West Chester	3	0.2	0.1	0.2
Ind: Muncie	7	0.4	0.1	0.2	P.R.: Bayamón	7	0.1	<0.1	0.1
Ind: New Albany	7	0.3	0.1	0.2	P.R.: Guayama	7	0.2	<0.1	0.1
Ind: Parke County *	7	0.6	0.1	0.2	P.R.: Ponce	7	0.1	<0.1	0.1
Ind: South Bend	6	0.3	0.1	0.1	P.R.: San Juan	6	0.2	<0.1	0.1
Ind: Terre Haute	6	0.3	0.1	0.2	R.I.: Providence	7	0.3	0.1	0.2
Iowa: Davenport	7	0.3	0.1	0.2	S.C.: Washington County *	7	0.3	0.1	0.2
Iowa: Delaware County *	4	0.2	0.1	0.2	S.C.: Columbia	6	0.5	0.1	0.2
Iowa: Des Moines	7	0.2	0.1	0.1	S.C.: Greenville	7	0.3	0.1	0.2
Iowa: Dubuque	7	0.3	0.1	0.2	S.C.: Richland County *	7	0.3	<0.1	0.1
Kans: Kansas City	7	0.2	0.1	0.1	S. Dak: Black Hills Forest *	7	0.3	0.1	0.2
Ky: Wichita	6	0.2	0.1	0.1	S. Dak: Sioux Falls	7	0.3	0.1	0.2
Ky: Ashland	7	0.3	0.1	0.2	Tenn: Chattanooga	6	0.3	<0.1	0.1
Ky: Covington	7	0.3	0.1	0.2	Tenn: Memphis	7	0.2	0.1	0.1
Ky: Louisville	7	0.3	0.1	0.2	Tenn: Nashville	7	0.2	0.1	0.1
La: New Orleans	7	0.2	0.1	0.1	Tex: Dallas	6	0.3	0.1	0.1
Maine: Acadia National Park *	7	0.3	0.1	0.1	Tex: Houston	6	0.2	<0.1	0.1
Md: Portland	6	0.3	<0.1	0.1	Tex: Matagorda County *	6	0.2	<0.1	0.1
Md: Baltimore	7	0.3	0.1	0.2	Tex: Pasadena	4	0.2	<0.1	0.1
Md: Calvert County *	6	0.2	0.1	0.1	Tex: San Antonio	7	0.2	<0.1	0.1
Mich: Detroit	7	0.3	0.1	0.2	Utah: Ogden	6	0.2	0.1	0.1
Minn: Duluth	7	0.3	0.1	0.1	Utah: Salt Lake City	7	0.3	0.1	0.2
Minn: Minneapolis	7	0.3	0.1	0.2	Utah: Burlington	7	0.3	0.1	0.2
Minn: Moorhead	7	0.3	<0.1	0.1	Utah: Orange County *	7	0.3	0.1	0.2
Minn: St. Paul	7	0.3	0.1	0.2	Va: Danville	5	0.4	0.1	0.2
Miss: Jackson	7	0.3	0.1	0.1	Va: Norfolk	7	0.3	0.1	0.1
Miss: Jackson County *	7	0.3	<0.1	0.1	Wash: Shenandoah Nat'l Park *	7	0.4	<0.1	0.1
Mo: Kansas City	7	0.2	0.1	0.2	Wash: Seattle	7	0.1	<0.1	0.1
Mo: St. Louis	7	0.4	0.1	0.2	W. Va: Charleston	6	0.3	0.1	0.2
Mo: Shannon County *	6	0.3	0.1	0.2	W. Va: Door County *	4	0.2	<0.1	0.1
Mont: Glacier National Park *	6	0.2	0.1	0.1	Wyo: Milwaukee	7	0.3	0.1	0.2
Nebr: Helena	7	0.4	0.1	0.2	Wyo: Cheyenne	7	0.2	0.1	0.1
Nebr: Omaha	7	0.3	0.1	0.2	Wyo: Yellowstone Nat'l Park *	7	0.4	0.1	0.2
Nebr: Thomas County *	7	0.3	0.1	0.2					

* Non-urban station.

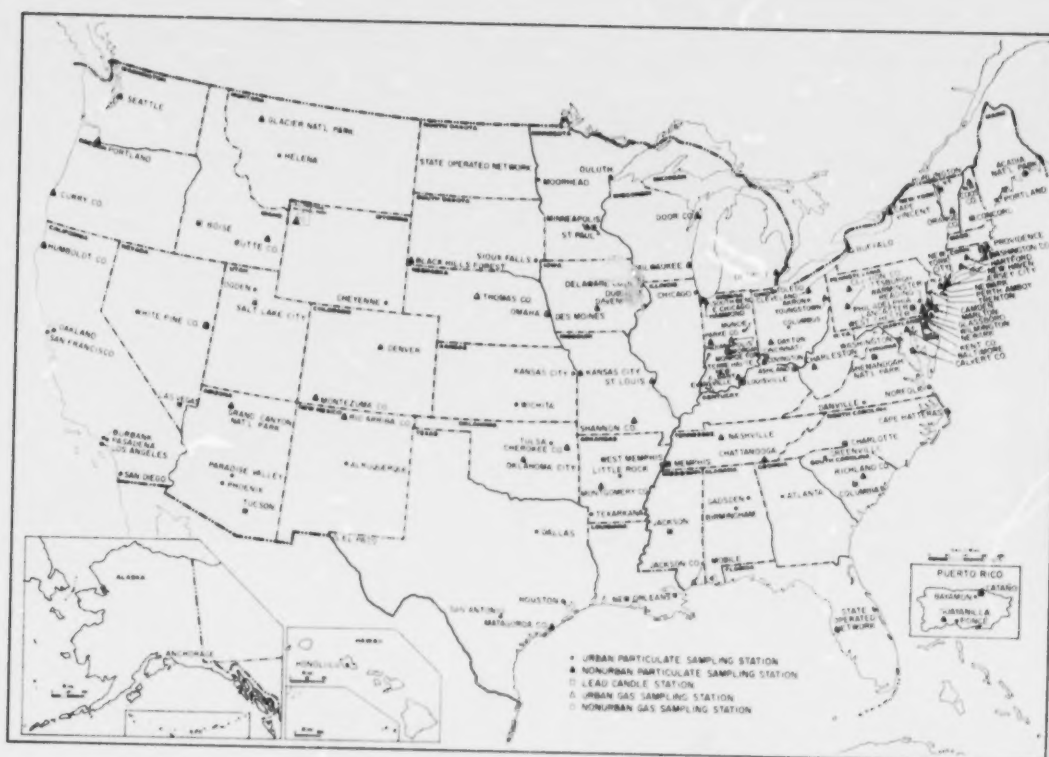


Figure 6. National Air Sampling Network locations, 1966

6. Surface Air Sampling Program— 80th Meridian Network January–December 1965²

*Health and Safety Laboratory
U.S. Atomic Energy Commission*

The Health and Safety Laboratory began its Surface Air Sampling Program in January 1963, as a continuation of the 80th Meridian Program conducted by the U.S. Naval Research Laboratory. The objectives of this program are to determine the concentrations of radioactivity in surface air in both hemispheres as a function of latitude and season, and to interpret these data in terms of the dominant meteorological and physical processes which are operative.

The basic network consists of a line of sites approximately along the 80th meridian extending from about 76°N to 53°S latitudes (figure

² Summarized from "Fallout Program Quarterly Summary Report," HASL-173, available from the Clearinghouse for Federal Scientific and Technical Information, 5285 Port Royal Road, Springfield, Virginia 22151.

7). Duplicate collections are made at the New York site which provide a measure of the reproducibility of sampling and analysis in this program. Additional sites in Hawaii and in the continental United States were implemented to supply data relating to possible longitudinal, coastal or altitude effects of surface air concentrations. The Environmental Science Services Administration maintains a collection site at the Amundson Scott Station in Antarctica. The air-filter samples from this site are also included in the HASL Program.

Sampling and analytical procedures

Approximately 1,400 cubic meters of ambient air per day are drawn through an 8-inch-diameter Microsorban filter. Each filter is changed on the 1st, 8th, 15th, and 22nd of the month or more frequently if the filter becomes clogged with debris suspended in the air. Under normal conditions, the filters from each station are compressed into a monthly composite and



Figure 7. 80th Meridian Network sampling stations

the gamma-ray spectrum of the composite is obtained by an 8- by 4-inch NaI (Thallium) crystal approximately 2 weeks after the last collection in the month. If a nuclear event occurs and measurable quantities of radioactivity are injected into the atmosphere, each filter collected in the same hemisphere in which the event takes place is assayed individually in an attempt to better delineate the disposition and dispersion of the nuclear debris during the ensuing weeks.

The integrated response between 100 KeV and 3.0 MeV is corrected by the average detection efficiency (35 percent) of the gamma-ray photons present in fallout and the total gamma-ray activity is reported in units of photons/min $\cdot$ 1,000 m². Average monthly gamma-ray concentrations are calculated by weighting the concentrations in each sampling interval by the relative period of time in the interval. After the gamma-ray measurements have been completed monthly composites from each site are submitted to contractor laboratories for radiochemical analyses.

Since the last major nuclear weapon test series occurred at the end of 1962, only the longer-lived artificially produced radionuclides were present in the filters analyzed. Consequently, emphasis was given to the determination of manganese-54, iron-55, strontium-90, cadmium-109, cesium-137, cerium-144, and at some sites, plutonium-238 and plutonium-239. Strontium-89 and zirconium-95 were analyzed in samples collected in May and June after the second Chinese nuclear test of May 14, 1965.

The longer-lived fission products and plutonium-239 concentrations should describe the general distribution in surface air of all previous nuclear weapons debris which was transferred from the lower stratosphere to the troposphere during the collection period of this report. Other tracer radionuclides can be associated with debris from a single detonation or a series of detonations. Manganese-54 and iron-55 were produced in large quantities in the 1961 and 1962 test series. Cadmium-109 was generated by the U.S. high-altitude test over Johnston Island on July 9, 1962. While plutonium-238 is present in low concentrations in nuclear weapons debris, about 17,000 curies of plutonium-238 were disseminated at high altitude in the stratosphere on April 21, 1964, during the re-entry burnup of a SNAP-9A power source.

During 1965, Food, Chemical and Research Laboratories, Inc., (FCRL) of Seattle, Wash., performed the analyses of most of the samples in this program. Isotopes, Inc., of Westwood, N.J., analyzed most of the samples collected at Westwood; Lima, Peru; and Chacataya, Bolivia. Hazelton-Nuclear Science Corporation of Palo Alto, California, analyzed practically all of the samples from Sterling, Virginia, and Antofagasta, Chile. Previous reports containing data on the HASL Surface Air Sampling Program are given in references (9-12).

Results

The updated activity concentrations in surface air during 1965 are presented in tables 7 through 17. The sites are listed according to latitude beginning with the most northern site at Thule, Greenland. The coded duplicate samples from the New York site were analyzed, and these results are also given in tables 7 through 17. Such duplicate samples were part of a quality control program maintained with Food, Chemical and Research Laboratories, Inc., in which coded duplicates, standards, and blanks were submitted with each shipment of samples. The results of the standards and blank analyses are reported in table 18.

The concentrations are reported at the midpoint of the collection month for the plutonium isotopes and the fission products and on the following dates for the induced radionuclides:

Manganese-54 and iron-55:

October 15, 1961

Cadmium-109:

July 9, 1962.

One standard deviation of the counting error for these data is always less than ± 20 percent and usually less than 10 percent unless otherwise indicated. Data are suspect when the concentration of a radionuclide is inconsistent with:

1. Its concentrations in samples adjacent in time and place
2. Concentrations of other radionuclides in the same sample.

Some of the plutonium-238 and -239 concentrations during October 1965 which were reported earlier (12) have been omitted in tables 16 and 17 because of analytical errors which have been uncovered but cannot be resolved.

Data reliability

According to Volk (13) an estimate of the standard deviation of an analysis can be obtained from duplicate measurements by the equation:

$$\sigma = 0.8862 \bar{d}$$

where σ = percent standard deviation

$\bar{d}$ = deviation between duplicate measurements expressed as percent of the mean.

Invoking this equation, the standard deviation for each duplicate measurement at New York is reported in tables 7 through 17 along with the average standard deviation for each radionuclide during the time interval covered by this report. Deviations are given only for duplicates where the counting error is less than ± 20 percent. The average percent standard deviation for all radionuclides except strontium-89 is 16 percent or better. The listed average percent standard deviation for strontium-89 is 45 percent. While the strontium-89 analysis is probably less reliable than the other radionuclide analyses, not enough duplicate strontium-89 measurements were performed to per-

mit an adequate evaluation of that reliability.

A blank is prepared by sprinkling a small amount of pre-1945 soil (<100 mg) onto an unexposed Microsorban filter. Then carbon soot from burning naphthalene is filtered onto the Microsorban paper for a few moments under laboratory conditions. This procedure produces blanks which are very similar in appearance and, in some respects, composition to the routine filters collected by this program. When the blanks are coded, as are all the filters submitted for radiochemistry, they are not readily distinguishable from routine samples.

A standard is prepared by evaporating weighed aliquots of standard solutions of various radionuclides calibrated at HASL onto a blank sample which was prepared by the procedure just described. However, since Microsorban is a polyethylene-base paper, it is not wetted by aqueous solutions. To avoid this problem, the tracer solutions were added to one of two pieces of backing paper which accompany each sample. The backing paper readily absorbs the tracer solutions, and is completely dissolved with the Microsorban filter prior to radiochemical analysis. The results of the coded blank and standard sample analyses are given in table 18.

Table 7. Gamma activity in surface air, January-December 1965

(gamma ray activity, photons/min • 1,000 m²)

Station	Latitude	Longitude	Elevation (feet)	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northern Hemisphere															
Thule, Greenland	76° 36'	68° 35'	259	184	132	287	242	206	143	112	72.3	52.2	41.0	30.5	43.2
Moosonee, Canada	51° 16'	80° 39'	10	98.3	132	183	206	236	379	167	45.3	30.2	24.0	14.7	21.3
Seattle, Wash.	47° 36'	122° 20'	3	68.4	147	342	138	138	244	77.9	47.0	50.6	30.3	25.9	27.4
Appleton, Wis.	44° 15'	88° 25'	229	133	188	295	235	283	716	261	74.8	34.0	31.8	26.6	25.8
Westwood, N.J.	41° 00'	74° 01'	38	143	202	202	234	508	537	324	78.9	52.0	35.4	—	—
New York, N.Y.	40° 48'	73° 58'	38	163	223	234	259	545	829	322	81.1	67.6	50.2	38.7	34.1
						220	264								
						227	261								
						±3.1	±1.8								
Sterling, Va.	38° 58'	77° 25'	76	140	209	177	217	419	647	218	89.3	47.8	31.7	38.2	31.1
Palo Alto, Calif.	37° 30'	122° 23'	19	95.4	227	311	166	208	264	71.6	52.1	70.1	35.2	41.0	29.9
Midwest City, Okla.	35° 25'	97° 30'	364	155	195	245	325	467	951	160	84.5	50.1	—	—	—
Norman, Okla.	35° 14'	97° 27'	364	—	—	—	—	—	—	—	—	—	21.9	35.2	41.3
Chattanooga, Tenn.	35° 03'	85° 20'	205	163	198	204	266	332	728	180	84.2	59.1	48.9	43.5	37.1
Miami, Fla.	25° 49'	80° 17'	4	165	198	224	346	407	452	106	49.4	40.7	37.0	40.9	41.6
Mauna Loa, Hawaii	19° 28'	155° 35'	3,401	128	310	209	144	647	393	103	55.3	33.4	35.5	20.4	30.1
San Juan, P.R.	18° 26'	66° 00'	10	111	133	186	222	123	627	101	47.3	22.5	17.4	14.0	15.8
Miraflores, C.Z.	9° 00'	79° 35'	10	74.8	84.4	29.0	125	99.3	—	—	—	—	—	—	—
Balboa, C.Z.	8° 58'	79° 34'	23	—	—	—	—	—	109	56.4	17.9	8.39	5.26	5.63	17.2
Southern Hemisphere															
Guayaquil, Ecuador	2° 10'	79° 52'	7	30.1	23.6	16.1	27.0	12.2	15.3	12.5	14.0	10.3	12.0	14.3	10.6
Lima, Peru	12° 01'	77° 01'	134	65.0	52.3	102	37.3	33.3	35.3	28.4	41.4	37.9	38.0	34.9	26.8
Chacaltaya, Bolivia	21° 21'	68° 07'	5,230	16.5	17.1	25.8	16.0	31.0	35.6	24.4	19.9	30.4	21.3	14.2	—
Antofagasta, Chile	23° 37'	70° 16'	519	60.4	54.9	48.4	41.3	35.9	34.2	40.7	43.9	54.3	25.5	31.7	—
Santiago, Chile	33° 27'	70° 42'	520	76.6	62.4	51.4	47.0	53.0	39.4	37.1	44.2	49.8	25.5	—	28.4
Puerto Montt, Chile	41° 27'	72° 57'	5	43.3	49.5	39.5	34.0	23.0	16.4	16.8	16.1	14.6	16.2	13.6	14.2
Punta Arenas, Chile	53° 08'	70° 53'	3	26.8	37.1	30.4	27.0	19.7	12.3	11.1	8.76	18.6	8.09	8.89	11.1

^a Data suspect.

^b Analysis performed by FCRL.

In the January and February sample shipment, the blank samples were separate and distinct from the standard samples. Thereafter, any particular quality-control sample might be a blank for certain radionuclides and a standard for others depending upon whether tracer solution was added or not. A review of the blank data in table 11 indicates that the laboratory contamination for most of the nuclides studied is either not measurable or at a level which is usually negligible with regard to the activity levels in the samples. A notable exception is manganese-54 because its contamination level approaches the activities measured in the filter samples collected at the low and high latitude stations of the Southern Hemisphere (Guayaquil and Punta Arenas) from about mid-1965.

FCRL has performed some plutonium-238 and plutonium-239-240 analyses on surface air filter samples beginning in June 1965. The previous plutonium analyses performed in this program were conducted by Hazleton Nuclear Science Corporation and Isotopes, Inc. The blank analyses which were performed by FCRL and are reported in table 18 indicate that since July 1965 the laboratory contamination for plutonium-238 at FCRL is, at times, equivalent to the activity levels measured in the samples. This in effect invalidates practically all of FCRL's plutonium-238 measurements. It should be stressed that plutonium-238 measurements of surface air filter samples are very difficult analyses which are compounded by the extremely minute quantity of plutonium-238 which is present.

The previous evaluation of the data in table 11 from January through June 1965 (11) suggested that there may have been serious errors at times in the preparation or processing of the standard samples or that the standards and their analyses are not wholly representative of the routine surface air samples. It was proposed that future standards would be prepared by dispersing the tracer solutions directly on the Microsorban filter with a wetting agent instead of on the backing paper so that the standard would more closely resemble the routine samples. Unfortunately, this modification was not put into effect until the November 1965 samples were submitted for analyses. However, extra care was taken in the preparation of the

July through October standards.

The overall accuracy of FCRL's analyses of samples which were collected in 1965 is reflected in the average percent deviation reported in table 18. There appears to be a negative bias for all radionuclides, most of them being accurate to within 15 percent. Cadmium-109 and plutonium-239 results are more extreme, being consistently low by an average of about 25 and 50 percent, respectively.

This behavior of the cadmium-109 and plutonium-239 data suggests that a sizable error exists in the calibration of the radioassay equipment for these two nuclides. However, the variability of the bias for these two nuclides argues that a more serious non-systematic error may also be involved such as impure separations, incorrect radiochemical yields, or unstable radioassay equipment. All cadmium fractions from samples collected during 1965 are being reassayed at HASL in an effort to resolve the uncertainties of analysis and in order to report lower levels of detection. Plutonium analyses have been suspended until the reliability of analysis which was demonstrated in early 1965 can be reestablished. The bulk of the plutonium analyses for 1965 which were reported by Isotopes, Inc., and Hazleton Nuclear Science Corporation appear to be internally reasonable and consistent.

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Table 8. Manganese-54 concentrations in surface air, January-December 1965

(concentrations, dpm/1,000 m³ of composite monthly samples decay corrected to October 15, 1961)

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northern Hemisphere												
Thule	302	238	445	373	255	120	91.7	98.9	90.3	80.1	151	93.2
Moosonee	156	215	274	313	^a 320	227	129	99.3	50.7	49.8	37.8	43.9
Seattle	382	170	382	232	229	196	73.2	—	—	—	—	—
Appleton	195	317	293	309	307	349	212	155	73.2	63.5	^b 36.0	60.5
Westwood	—	228	175	302	275	271	—	—	—	—	—	—
New York	218	330	290	355	327	354	236	159	102	85.7	76.6	71.2
	204	324	288	342	303	417	265	164	98.1	82.5	55.0	^a 62
	211	327	289	349	315	386	251	162	100	84.1	65.9	66.8
	±5.8	±1.6	±0.1	±3.3	±6.1	±14	±10	±2.7	±3.5	±3.4	±29	±12
Sterling	222	356	296	285	448	^a 445	180	^a 124	^a 102	^a 60.0	67.4	61.2
Palo Alto	147	381	462	233	277	171	119	94.6	112	77.6	70.0	69.7
Midwest City	231	315	349	468	375	300	176	107	81.7	—	—	—
Norman	—	—	—	—	—	—	—	—	—	—	—	—
Chattanooga	194	272	238	280	333	212	166	111	71.7	110	85.3	ND
	—	—	—	—	—	—	—	—	—	79.5	^b 50.5	79.2
Miami	263	332	334	516	572	223	87.4	63.5	52.5	75.3	87.0	100
Mauna Loa	199	536	346	209	183	189	129	73.4	45.1	60.0	36.2	60.4
San Juan	176	210	177	332	154	176	98.4	56.5	^a 41	27.7	^a 20	37.1
Miraflores	114	131	173	160	78.2	—	—	—	—	—	—	—
Balboa	—	—	—	—	—	26.9	^b 22.6	^a 14	ND	^a 6.8	^a 9.3	32.8
Southern Hemisphere												
Guayaquil	30.4	32.5	ND	^a 9.4	^a 7.7	^a 5.2	^a 17	^a 8.5	^a 6.4	21.1	^a 18	^a 24
Lima	—	45.0	44.4	43.5	^b 292	25.5	^a 34.8	—	—	^b 81.7	—	60.4
Chacaltaya	—	16.4	20.0	^b 269	^b 538	26.0	—	—	—	40.5	—	—
Antofagasta	98.5	72.4	60.2	54.7	^a 49	51.0	52.7	63.7	95.4	41.2	—	—
Santiago	87.5	67.9	54.3	31.5	26.9	^a 19	39.8	42.0	50.0	54.2	—	—
Puerto Montt	63.3	72.0	49.6	46.9	35.0	19.9	^a 35	13.2	^a 18	^a 21.8	^a 18	^a 25
Punta Arenas	31.3	50.2	38.0	32.8	29.3	^a 9.7	^a 16	^a 7.7	^a 31	^a 15	^a 9.0	^a 12

^a Counting error is 20-50 percent.

^b Data suspect.

^c Analysis performed by FCRL.

^d Counting error is 51-100 percent.

ND, not detectable.

Table 9. Iron-55 concentrations in surface air, January-December, 1965

(concentrations, dpm/1,000 m³ of composite monthly samples decay corrected to October 15, 1961)

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northern Hemisphere												
Thule	352	330	521	560	235	124	124	120	108	74.1	142	99.3
Moosonee	199	279	431	394	434	291	148	126	60	56.2	53.4	43.7
Seattle	626	265	629	315	302	299	118	110	96.2	^a 9.42	^a 1.73	63.0
Appleton	292	424	383	406	474	282	213	213	62.9	111	70.1	89.6
Westwood	264	257	215	365	588	380	242	176	83.6	68.8	—	—
New York	338	534	435	327	582	479	292	182	153	140	105	97.7
	325	557	122	406	527	536	337	214	125	95.7	103	55.6
	332	546	435	367	554	508	315	198	139	118	104	76.6
	±3.4	±3.7	—	±19	±8.8	±9.7	±13	±14	±18	±33	±1.7	±49
Sterling	—	^a 202	165	438	457	235	265	134	69.6	79.6	98.0	77.5
Palo Alto	208	488	668	275	271	201	194	100	90.4	117	60.8	70.8
Midwest City	324	397	484	516	536	386	206	139	85.1	—	—	—
Norman	—	—	—	—	—	—	—	—	—	—	—	—
Chattanooga	353	—	381	550	602	288	263	151	78.2	138	93.6	106
	—	—	—	—	—	—	—	—	—	161	105	132
Miami	340	490	400	578	631	268	121	68.0	67.9	65.7	81.8	134
Mauna Loa	237	765	376	200	239	244	156	92	56.8	84.2	53.8	77.2
San Juan	242	291	280	438	185	197	128	67.5	41.3	38.8	41.5	33.2
Miraflores	155	198	227	221	110	—	—	—	—	—	—	—
Balboa	—	—	—	—	—	^a 72	56.4	^b 24	^b 9.9	^b 8.5	^a 41.6	29.6
Southern Hemisphere												
Guayaquil	45.3	31.1	25.9	^a 8.7	ND	ND	^b 22	^a 11	ND	^a 7.4	^a 50.5	^b 26
Lima	103	49.6	55.3	^b 38	24.6	32.6	^a 70.5	45.9	65.6	^b 112	—	63.1
Chacaltaya	27.1	19.2	25.3	10.8	15.6	27.9	^b 22.7	27.7	43.8	48.5	—	—
Antofagasta	52.8	—	76.9	62.6	43.7	48.8	61.0	66.8	152	54.0	—	—
Santiago	138	96	^a 53	^b 41	^b 76	ND	^a 111	^b 54	^b 34	^b 83	—	80.9
Puerto Montt	97.5	97.2	70.8	47.5	36.1	36.6	^b 15	15.0	28.5	37.2	25.3	26.4
Punta Arenas	60.5	77.5	45.9	40.7	18.0	^b 21	24.2	^b 13	^a 18	^b 34	^b 31	^a 53

^a Data suspect.

^b Analysis performed by FCRL.

^c Counting error is 20-50 percent.

^d Counting error is 51-100 percent.

ND, not detectable.

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Table 10. Strontium-89 concentrations in surface air, January-December 1965
(concentrations, dpm/1,000 m³ at midmonth)

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northern Hemisphere												
Thule												
Moosonee					ND	* 10.3	9.73					
Seattle					ND	39.0	54.3					
Appleton					ND	ND	19.8					
Westwood					ND	113	37.2					
New York					ND	46.8	—					
						82.5	40.9					
						99.3	98.0					
					^b 13.6	90.9	69.5					
						±18	±78					
Sterling					19.5	93.2	47.4					
Palo Alto					ND	37.7	30.4					
Midwest City					21.8	107	53.2					
Norman					—	—	—					
Chattanooga					44.0	83.0	ND					
Miami												
Mauna Loa					^c 2.6	58.3	14.6					
San Juan					67.3	56.0	ND					
Miraflores					5.6	74.0	* 18					
Balboa					* 2.0	—	—					
					—	14.5	11.6					
Southern Hemisphere												
Guayaquil					ND	ND	5.2					
Lima					ND	ND	* 8.2					
Chacaltaya					ND	0.8	—					
Antofagasta					ND	1.2	ND					
Santiago					* 2.9	—	—					
Puerto Montt					ND	ND	* 11					
Punta Arenas					ND	ND	ND					

* Counting error is 20-50 percent.

^b Monthly strontium-89 concentration calculated from analyses of several highly radioactive daily samples.

^c Analysis performed by FCRL.

^d Counting error is 50-100 percent.

ND, not detectable.

Table 11. Strontium-90 concentrations in surface air, January-December 1965
(concentrations, dpm/1,000 m³ at midmonth)

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northern Hemisphere												
Thule	36.6	24.1	52.3	42.9	31.5	13.7	9.73	14.6	11.5	9.23	17.7	11.2
Moosonee	18.8	24.9	28.5	31.7	33.5	28.6	11.6	13.3	5.69	5.56	4.89	5.2
Seattle	52.5	22.3	52.5	26.1	24.9	29.4	10.8	11.3	7.8	7.35	6.54	5.63
Appleton	24.3	35.2	34.2	34.5	40.5	44.1	26	19.7	8.85	9.96	6.35	7.1
Westwood	25.9	33.3	37.3	44.2	42.6	29.6	33.5	* 34.7	11.6	11.8	—	—
New York	26.3	33.1	35.8	45.2	39.6	46.0	26.3	23.5	15.7	11.1	10.5	8.6
	26.7	39.0	32.9	38.5	43.0	56.2	22.3	22.3	14.5	10.1	8.57	7.5
	26.5	36.0	34.4	41.9	41.3	51.1	24.3	22.9	15.1	10.6	9.54	8.05
	±1.3	±14	±7.4	±14	±7.2	±18	±15	±4.6	±7	±8.4	±18	±12
Sterling	26.9	36.7	31.3	39.8	38.8	28.4	* 33.4	^b 19.2	10.1	^b 8.63	9.2	8.7
Palo Alto	18.8	39.9	59.1	29.6	28.8	19.9	13.8	11.6	15.9	9.28	9.23	6.7
Midwest City	28.7	33.6	40.5	56.8	43.3	42.2	18.2	16.3	10.6	—	—	—
Norman	—	—	—	—	—	—	—	—	—	—	—	—
Chattanooga	29.4	34.2	34.6	43.7	44.4	32.8	19.1	15.0	11.7	11.8	9.89	13.3
Miami	31.8	35.2	35.5	52.5	55.0	25.6	10.4	8.23	6.22	8.72	9.67	10.1
Mauna Loa	25.2	50.6	34.0	28.1	20.4	22.8	17.2	9.74	5.73	7.84	5.17	8.6
San Juan	21.5	25.0	23.6	41.4	14.7	21.9	12.8	7.72	3.4	3.52	3.12	4.1
Miraflores	13.8	14.4	19.3	23.2	9.22	—	—	—	—	—	—	—
Balboa	—	—	—	—	—	4.32	5.2	2.93	0.92	0.95	0.94	3.3
Southern Hemisphere												
Guayaquil	5.54	3.31	2.17	* 0.91	0.90	1.22	1.38	1.46	1.59	2.4	3.10	2.4
Lima	* 5.21	8.34	9.46	^b 4.69	4.32	4.30	^b 4.63	7.08	9.98	^b 10.5	8.18	5.4
Chacaltaya	* 7.9	2.21	3.29	1.53	2.17	2.88	^d 2.39	3.44	5.88	4.64	3.15	—
Antofagasta	12.7	11.5	8.73	7.19	3.67	4.94	9.30	9.07	13.2	1.34	8.64	—
Santiago	17.4	12.7	9.72	6.05	5.85	3.64	6.92	6.28	8.9	6.43	—	—
Puerto Montt	11.4	10.6	8.31	4.9	4.26	3.21	2.67	2.8	3.47	3.5	2.62	5.2
Punta Arenas	6.00	7.95	6.23	5.10	3.50	2.21	2.19	1.61	4.32	1.97	1.57	2.4

* Data suspect.

^b Analysis performed by FCRL.

* Counting error is 20-50 percent.

^d Counting error is 51-100 percent.

Table 12. Zirconium-95 concentrations in surface air, January-December 1965

(concentrations, dpm/1,000 m³ at midmonth)

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northern Hemisphere												
Thule	1.21	* 0.59	—	—	17.5	22.6	13.5	—	—	—	—	—
Moosonee	1.27	* 0.86	—	—	15.1	51.0	15.0	—	—	—	—	—
Seattle	1.13	* 0.44	1.13	—	1.09	44.1	5.45	—	—	—	—	—
Appleton	1.28	* 0.55	—	—	11.4	91.7	21.1	—	—	—	—	—
Westwood	ND	ND	—	—	3.0	92.3	—	—	—	—	—	—
New York	0.68	* 0.40	—	—	11.1	95.6	20.1	—	—	—	—	—
	0.90	* 0.50	—	—	11.3	100	23.1	—	—	—	—	—
	0.79	0.45	—	—	11.2	97.8	21.6	—	—	—	—	—
	±25	±19	—	—	±1.9	±4	±12	—	—	—	—	—
Sterling	ND	^b 26.4	—	—	6.32	71.3	17.5	—	0.576	—	—	—
Palo Alto	0.77	0.99	—	—	13.6	41.7	5.54	—	—	—	—	—
Midwest City	0.75	1.09	—	—	29.5	97.2	7.46	—	—	—	—	—
Norman	—	—	—	—	—	—	—	—	—	—	—	—
Chattanooga	0.99	* 0.69	—	—	6.15	75.0	7.2	—	—	—	—	—
Miami	0.97	1.21	—	—	13.5	43.6	5.0	—	—	—	—	—
Mauna Loa	0.73	1.40	—	—	55.6	28.7	* 1.3	* 0.33	—	—	—	—
San Juan	* 0.64	ND	—	—	3.70	72.3	14.4	—	—	—	—	—
Miraflores	* 0.53	* 0.41	—	—	4.58	—	—	—	—	—	—	—
Balboa	—	—	—	—	—	8.04	4.2	—	—	—	—	—
Southern Hemisphere												
Guayaquil	* 0.15	—	—	—	* 0.37	1.72	ND	—	—	—	—	—
Lima	ND	—	—	—	ND	0.809	^d ND	—	—	—	—	—
Chacaltaya	ND	—	—	—	—	0.577	—	—	—	—	—	—
Antofagasta	^b 5.8	ND	—	—	0.678	0.499	ND	—	—	—	—	—
Santiago	* 0.16	—	—	—	* 0.17	ND	ND	—	—	—	—	—
Puerto Montt	* 0.21	—	—	—	ND	ND	ND	—	—	—	—	—
Punta Arenas	ND	—	—	—	ND	ND	ND	—	—	—	—	—

* Counting error is 20-50 percent.

^b Data suspect.

* Counting error is 51-100 percent.

^d Analysis performed by FCRL.

ND, not detectable.

Table 13. Cadmium-109 concentrations in surface air, January-December 1965

(concentrations, dpm/1,000 m³ of composites monthly samples decay corrected to July 9, 1962)

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northern Hemisphere												
Thule	ND	* 0.17	ND	ND	* 0.52	ND	ND	^b 0.38	* 0.20	* 0.13	^b 0.31	ND
Moosonee	ND	ND	ND	ND	* 0.64	ND	* 0.53	* 1.7	* 0.10	ND	* 0.11	* 0.23
Seattle	ND	ND	ND	ND	^b 0.50	ND	ND	ND	^b 0.30	ND	ND	^b 0.34
Appleton	ND	ND	ND	ND	^b 0.82	^b 0.44	ND	ND	^b 0.18	* 0.92	* 0.82	ND
Westwood	ND	ND	ND	0.227	ND	^b 0.31	* 0.32	0.245	* 3.38	^b 0.23	—	—
New York	ND	* 0.38	ND	ND	^b 2.22	ND	ND	^b 0.29	^b 0.30	ND	* 0.33	ND
	ND	ND	ND	ND	* 1.3	* 0.47	ND	ND	* 0.12	ND	ND	* 0.19
					* 1.8				* 0.21			
Sterling	0.235	ND	^b 0.15	^b 0.14	0.17	0.323	0.920	* ^d 1.8	0.576	^d ND	^b 0.022	^b 0.38
Palo Alto	ND	ND	* 0.16	* 0.34	ND	ND	ND	^b 0.51	ND	ND	^b 0.37	ND
Midwest City	^b 0.09	ND	ND	ND	ND	^b 0.68	* 0.65	* 1.8	* 0.16	—	—	—
Norman	—	—	—	—	—	—	—	—	—	—	—	—
Chattanooga	ND	ND	ND	* 0.40	* 1.00	* 0.55	ND	* 0.31	* 0.11	ND	^b 0.38	^b 0.22
											ND	* 0.19
Miami	ND	* 0.24	ND	* 0.22	^b 1.16	ND	ND	* 0.26	* 0.19	ND	^b 0.36	* 0.16
Mauna Loa	ND	ND	^b 0.58	* 0.22	ND	ND	ND	—	^b 0.18	ND	ND	^b 0.20
San Juan	ND	ND	ND	ND	^b 0.83	* 0.27	* 0.24	* 0.11	ND	ND	ND	* 0.18
Miraflores	ND	ND	ND	ND	ND	—	—	—	—	—	—	—
Balboa	—	—	—	—	—	* 0.63	ND	* 0.28	ND	ND	* 0.41	ND
Southern Hemisphere												
Guayaquil	ND	* 0.22	ND	ND	* 0.58	^b 1.28	ND	ND	^b 0.24	* 0.17	* 0.35	^b 0.18
Lima	ND	ND	ND	^b ND	^b 0.38	ND	^d 0.45	^b 0.50	* 1.86	^b ND	^b 0.68	* 0.36
Chacaltaya	ND	ND	ND	^b 0.62	^b 0.079	^b 0.12	ND	ND	* 2.99	^b 0.19	0.213	—
Antofagasta	0.38	0.142	0.227	0.381	0.265	0.256	0.572	0.324	0.496	^b 0.32	ND	—
Santiago	^b 0.83	* 0.46	* 0.98	^b 0.40	^b 1.5	ND	^b 0.78	^b 0.54	ND	ND	—	* 0.32
Puerto Montt	^b 0.57	^b 0.60	^b 0.61	ND	^b 0.62	^b 0.54	ND	^b 0.71	* 0.25	^b 0.48	ND	* 0.741
Punta Arenas	ND	* 0.50	^b 0.38	ND	^b 0.90	* 0.36	^b 0.48	* 0.13	1.17	ND	^b 0.37	^b 0.56

* Counting error is 51-100 percent.

^b Counting error is 20-50 percent.

* Data suspect.

^d Analysis performed by FCRL.

ND, not detectable.

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Table 14. Cesium-137 concentrations in surface air, January-December 1965

(concentrations, dpm/1,000 m³ at midmonth)

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northern Hemisphere												
Thule	51.0	31.1	72.9	73.9	37.7	18.3	18.5	22.1	18.7	14.1	25.3	20.5
Moosonee	25.5	30.9	45.4	61.0	50.1	38.4	28.4	21.3	9.45	9.03	8.19	10.0
Seattle	80.0	31.1	80.0	34.5	31.0	32.6	19.7	—	—	—	—	—
Appleton	36.7	44.2	57.6	69.2	53.4	64.1	49	33.6	11.3	12.6	10.0	12.9
Westwood	54.5	46.5	43.8	56.0	48.1	47.1	—	—	—	—	—	—
New York	42.4	51.3	54.5	73.1	56.5	67.0	55.2	36.2	24.3	19.2	16.4	14.9
	38.4	61.0	53.0	81.0	58.9	69.1	59.6	36.1	21.3	23.6	13.1	15.5
	40.4	56.2	53.8	77.1	57.7	68.0	57.4	36.1	22.8	21.4	14.8	15.2
	±8.8	±15	±2.5	±8.8	±3.6	±2.7	±6.8	±0.24	±13	±18	±20	±3.5
Sterling	39.8	49	42.4	51.2	69.8	51.7	35.3	*27.4	17.2	*11.2	13.8	14.4
Palo Alto	23.2	54.5	81.7	49.9	46.6	29.2	24.9	19.5	24.7	15.3	13.5	13.7
Midwest City	42.5	49.1	65.6	95.8	62	51.6	40.8	26.5	16.2	—	—	—
Norman	—	—	—	—	—	—	—	—	—	22.1	16.3	24.2
Chattanooga	42.9	46.2	50.1	83.6	60.0	36.4	43.0	24.3	17.4	18.3	1.0	24.3
Miami	45.4	47.2	59.0	100	78.0	37.7	19.0	12.7	9.30	13.4	13.9	22.6
Mauna Loa	33.3	75.7	56.9	42.3	24.8	31.2	26.0	15.6	8.6	16.9	7.45	14.9
San Juan	29.0	30.2	31.7	67.3	21.1	26.1	20.1	13.1	5.68	5.63	4.18	7.01
Miraflores	19.4	19.2	29.4	35.5	10.1	—	—	—	—	—	—	—
Balboa	—	—	—	—	—	6.53	9.0	4.41	1.35	*2.80	1.29	5.74
Southern Hemisphere												
Guayaquil	7.50	5.39	3.35	1.92	1.26	1.58	2.99	3.19	2.63	3.78	4.85	4.41
Lima	13.5	29.5	31.8	*19.0	13.4	9.15	*8.05	—	—	*11.7	—	12.2
Chacaltaya	3.86	2.80	4.47	1.87	3.32	2.50	—	—	—	6.7	—	—
Antofagasta	20.2	20.8	10.4	5.58	7.09	5.90	11.8	*9.94	10.7	9.48	—	—
Santiago	22.6	16.2	13.4	12.4	8.37	5.29	12.9	12.4	14.6	9.80	—	10.8
Puerto Montt	14.5	13.5	11.2	9.37	5.1	3.89	3.90	5.42	5.25	5.25	4.15	6.65
Punta Arenas	8.07	10.9	8.25	7.16	4.24	2.48	3.40	2.52	6.52	3.16	2.98	4.16

* Analysis performed by FCRL.

b Data suspect.

Table 15. Cerium-144 concentrations in surface air, January-December 1965

(concentrations, dpm/1,000 m³ at midmonth)

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northern Hemisphere												
Thule	182	120	243	173	105	55.5	39.8	43.5	32.0	23.5	30.1	23.9
Moosonee	109	111	144	148	125	100	58	38.3	18.9	14.3	11.4	12.8
Seattle	244	120	244	104	87	123	42.5	34.0	26.4	17.6	15.2	16.4
Appleton	118	150	166	154	195	182	105	64	20.5	21.8	15.6	15.9
Westwood	116	143	135	184	148	152	107	74.7	30.7	25.1	—	—
New York	148	192	150	174	148	187	113	67.0	39.7	20.7	21.8	18.4
	143	181	155	171	141	210	122	62.0	33.0	29.6	20.0	18.5
	146	186	153	172	144	199	118	64.5	36.4	29.7	29.0	18.4
	±3.0	±5.2	±2.9	±1.5	±4.3	±9.7	±6.5	±16	±16	±0.29	±7.6	±4.8
Sterling	146	125	156	181	215	155	100	*55.6	*38.3	*19.6	21.4	18.6
Palo Alto	93	188	240	108	157	74.2	50.5	39.4	42	23.6	21.0	17.1
Midwest City	134	162	196	224	151	158	76.3	45.2	26.7	—	—	—
Norman	—	—	—	—	—	—	—	—	—	33.2	25.8	24.0
Chattanooga	144	157	144	137	170	132	88.2	45.2	31.0	28.6	22.8	26.1
Miami	156	168	188	262	189	107	44.5	24.4	21.4	21.7	23.3	25.7
Mauna Loa	116	269	165	101	80.0	87.2	54.6	29.8	15.2	19.7	12.4	17.3
San Juan	110	109	102	176	36.2	92.0	41.5	26.8	9.92	8.80	7.72	8.04
Miraflores	73.6	69.5	74.3	89.3	57.7	—	—	—	—	—	—	—
Balboa	—	—	—	—	—	20.2	20.8	9.08	2.5	2.3	2.39	6.64
Southern Hemisphere												
Guayaquil	21.7	12.1	9.03	16.5	4.13	4.64	4.73	4.59	4.15	6.45	5.81	5.40
Lima	38.2	29.5	31.8	*19.0	13.4	9.15	*15.0	17.6	22.4	*21.3	17.5	12.6
Chacaltaya	11.5	8.5	12.1	5.62	6.01	7.84	*7.7	8.98	13.4	9.62	6.15	—
Antofagasta	54.9	42.9	30.1	25.6	—	16.1	23.9	28.6	42.4	13.1	17.7	—
Santiago	61.1	41.7	37.1	26.7	18.8	13.1	18.5	18.6	22.2	13.7	—	13.3
Puerto Montt	39.0	34.9	28.8	21.6	13.8	10.0	5.9	8.24	8.17	8.38	5.95	13.6
Punta Arenas	22.4	29.9	38.1	16.7	10.2	6.83	5.85	3.55	11.0	*6.64	3.36	*40.2

* Analysis performed by FCRL.

b Data suspect.

c Counting error is 20-50 percent.

Table 16. Plutonium-238 concentrations in surface air, January-December 1965

(concentrations, dpm/1,000,000 m³ at midmonth)

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northern Hemisphere												
Thule								* 10	ND	* 2.2		7.1
Monrovia								ND	ND	ND	* 4.4	9.7
Seattle											ND	* 7.4
Appleton	* 15	ND	* 16	67.0	* 14	29.6	26.6		* 3.0	7.62		ND
Westwood						* 13			ND	* 2.7		
New York									ND	* 6.1	* 4.8	* 17
										±4.4	* 3.4	ND
										08	±4.1	
											30	
Sterling	* 10	* 26	22.5	27	22.3	19.6	* 15	* ND	* 5.1	* 16	* 4.6	* 2.6
Palo Alto												ND
Midwest City												* 2.5
Norman												ND
Chattanooga						ND						ND
Miami												ND
Mauna Loa												21.3
San Juan												ND
Miraflores												* 4.6
Balboa												* 2.6
Southern Hemisphere												
Guayaquil												
Lima	* 5.0	ND	* 4.2	* 5.4	* 5.9	* 2.4	* ND				ND	* 4.6
Chacaltaya	ND	21.6	* 3.5	* 4.7	12.5	ND	7.64		* 4.0		* 2.5	* 11
Antofagasta	* 7.7	10.7	28.6	11.7	* 7.9	* 5.4	* 3.6		* 4.8		* 5.1	
Santiago								* 3.0	* 9.4	ND	8.09	10.8
Puerto Montt										ND	* 4.3	ND
Punta Arenas									ND		ND	* 4.3

* Counting error is 51-100 percent.
 * Counting error is 20-50 percent.
 * Analysis performed by FCRL.
 * Data suspect.
 ND, not detectable.

Table 17. Plutonium-239 concentrations in surface air, January-December 1965

(concentrations, dpm/100,000 m³ at midmonth)

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northern Hemisphere												
Thule								16.0	13.5	10.7		12.9
Monrovia												5.5
Seattle								13.3	10.0		4.43	8.29
Appleton											17.4	
Westwood	71.7	* 74	66.6	* 261	66.2	88.6	49.4		18.4	14.7	* 3.06	7.00
New York						48.5			15.0	14.9		10.1
									13.1	13.4	10.2	7.94
									±14.1	±14.2	±9.72	±9.02
									12	9.4	8.8	22
Sterling	84.4	97.9	60.3	67.6	91.3	78.6	33.6	21	15.4	9.80		9.52
Palo Alto										* 8.41	9.80	10.0
Midwest City												13.4
Norman												11.0
Chattanooga						39.0						13.6
Miami												9.1
Mauna Loa												3.14
San Juan											* 1.57	
Miraflores												2.78
Balboa											* 0.29	
Southern Hemisphere												
Guayaquil												
Lima	22.3	12.0	12.0	* 5.6	7.45	6.47	* 5.35		9.42		* 1.4	2.44
Chacaltaya	3.9	* 259	4.29	* 3.6	5.36	4.22	4.18		5.35		10.8	7.05
Antofagasta	31.2	26.4	* 0.94	9.53	16.5	7.60	8.22	10.8	24.0	* 2.0	3.67	
Santiago										* 5.83	9.12	
Puerto Montt										* 6.26		6.47
Punta Arenas										ND	* 1.45	* 2.67
									* 25		* 0.63	1.86

* Data suspect.
 * Counting error is 20-50 percent.
 * Counting error is 51-100 percent.
 ND, not detectable.

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Table 18. Analyses of coded blank and standard samples during 1965

Radionuclide	Sample	Report date							
		January 15				February 15			
		A *	B *	C *	D *	A *	B *	C *	D *
Manganese-54	Added Found % Deviation	0 ND	4,450 3,200 -28	0 ND	0 ND	134,000 94,300 -30	179,000 143,000 -20	0 ND	0 ND
Iron-55	Added Found % Deviation	0 ND	42,300 4,320	0 ND	0 ND	144,000 131,000 +4.9	187,000 204,000 +9.1	0 +800	0 ND
Strontium-89	Added Found % Deviation								
Strontium-90	Added Found % Deviation	368 391 +6.2	2,300 2,430 +1.7	0 6.2	0 +1.0	16,400 13,900 -15	2,450 2,180 -11	0 ND	0 ND
Zirconium-95	Added Found % Deviation	280 290 +3.6	0 ND	0 +10	0 +12	0 ND	0 ND	0 +4.4	0 ND
Cadmium-109	Added Found % Deviation	0 ND	0 ND	0 ND	0 ND	4,470 4,100 -8.3	10,700 6,240 -42	0 ND	0 ND
Cesium-137	Added Found % Deviation	366 370 +1.1	4,510 4,130 -8.4	0 +1.9	0 +2.4	3,250 2,960 -8.9	3,350 2,680 -14	0 +0.99	0 ND
Cerium-144	Added Found % Deviation	4,000 3,870 -3.2	0 45.7	0 +1.9	0 16	7,280 6,760 -9.8	8,130 7,800 -4	0 35	0 10
Plutonium-238	Added Found % Deviation								
Plutonium-239	Added Found % Deviation								
		March 15				April 15			
		A	B	C	D	A	B	C	
Manganese-54	Added Found % Deviation	0 ND	104,000 88,200 -15	0 +709	103,000 77,100 -25	0 ND	0 +210	0 ND	
Iron-55	Added Found % Deviation	106,000 +9,520	199,000 16,700	0 ND	0 +320	109,000 94,300 -13	0 +780	0 +300	
Strontium-89	Added Found % Deviation					39,700 32,300 -19			
Strontium-90	Added Found % Deviation	0 ND	2,160 1,980 -8.3	15,300 13,800 -9.8	0 1.6	5,720 6,150 +7.5	0 1.6	0 ND	
Zirconium-95	Added Found % Deviation		27,500 54,600 +98		10,700 23,100 +116				
Cadmium-109	Added Found % Deviation	0 +30	999 859 -14	7,120 6,240 -12	0 +12	4,240 2,440 -42	0 ND	0 ND	
Cesium-137	Added Found % Deviation	0 3.24	7,710 7,100 -7.9	0 +2.2	1,710 1,610 -5.8	0 4.51	0 6.56	0 4.46	
Cerium-144	Added Found % Deviation	0 28.8	12,900 13,100 +1.5	0 19.8	9,720 8,160 -16	0 32.4	0 20.5	0 ND	
Plutonium-238	Added Found % Deviation								
Plutonium-239	Added Found % Deviation								

See footnotes at end of table.

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Table 18. Continued—Analyses of coded blank and standard samples during 1965

Radionuclide	Sample	Report date							
		May 15				June 15			
		A	B	C	D	A	B	C	D
Manganese-54	Added Found % Deviation	0 ND	246,000 283,000 +15	0 ND	246,000 216,000 -12	0 ND	170,000 116,000 -32	0 ND	236,000 185,000 -22
Iron-55	Added Found % Deviation	136,000 104,000 -24	0 ND	0 +400	92,300 96,090 +4	22,200 30,800 +39	0 ND	0 ND	177,000 161,000 -9
Strontium-89	Added Found % Deviation	0 ND	0 ND	0 ND	0 +540	0 ND	0 ND	0 ND	0 ND
Strontium-90	Added Found % Deviation	0 ND	0 ND	4,460 4,320 -3.1	5,470 4,820 -12	0 ND	0 ND	7,910 3,140 -60	6,840 6,690 -2.2
Zirconium-95	Added Found % Deviation	0 ND	3,640 2,830 -22	0 ND	3,510 3,030 -14	0 25	1,950 1,880 -3.6	0 ND	2,480 2,150 -13
Cadmium-109	Added Found % Deviation	0 +32	0 ND	1,990 1,960 -1.5	1,660 932 -44	0 +32	0 +13	4,030 2,100 -48	3,860 2,710 -30
Cesium-137	Added Found % Deviation	0 ND	1,660 +935 -44	0 ND	1,850 1,390 -25	0 +0.65	3,550 3,100 -13	0 +1.6	6,080 4,740 -22
Cerium-144	Added Found % Deviation	0 +3.6	8,680 7,770 -10	0 140	23,500 +7,560 -68	0 ND	14,500 +5,960 -59	0 ND	17,000 15,500 -8.8
Plutonium-238	Added Found % Deviation	0 ND	0 ND	0 ND	0 ND	0 ND	0 ND	0 ND	0 ND
Plutonium-239	Added Found % Deviation	15.6 9.01 -42	0 ND	0 ND	0 ND	15.6 9.01 -42	0 ND	0 ND	33.9 16.1 -53
		July 15			August 15				
		A	B	C	A	B	C		
Manganese-54	Added Found % Deviation	0 ND	66,600 42,400 -36	0 ND	29,500 26,800 -9.2	0 ND	32,400 29,400 -9.3		
Iron-55	Added Found % Deviation	0 +410	25,700 22,500 -13	0 ND	0 +240	29,100 25,000 -14	36,000 29,400 -18		
Strontium-89	Added Found % Deviation	0 ND	3,810 3,660 -3.9	0 +5.46	0 ND	0 ND	0 ND		
Strontium-90	Added Found % Deviation	0 0.63	913 884 -3.2	0 +3.99	484 470 -2.9	468 439 -1.9	0 0.989		
Zirconium-95	Added Found % Deviation	0 275	1,120 1,464 +31	0 ND	0 ND	0 ND	0 ND		
Cadmium-109	Added Found % Deviation	0 ND	1,130 840 -29	0 +8.8	438 102 -77	523 482 -7.8	0 ND		
Cesium-137	Added Found % Deviation	0 2.61	29,700 28,900 -2.7	0 1.68	3,300 3,330 +0.91	0 3.11	4,160 4,260 +2.4		
Cerium-144	Added Found % Deviation	0 ND	5,220 4,800 -8	0 ND	1,560 1,440 -7.7	0 ND	1,550 1,420 -8.4		
Plutonium-238	Added Found % Deviation	0 ND	0 ND	0 +0.10	0 ND	0 1.94	0 ND		
Plutonium-239	Added Found % Deviation	0 ND	68.3 ND	0 ND	0 ND	15.1 6.88 -54	8.77 5.59 -36		

See footnotes at end of table.

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Table 18. Continued—Analyses of coded blank and standard samples during 1965

Radionuclide	Sample	Report date							
		May 15				June 15			
		A	B	C	D	A	B	C	D
Manganese-54	Added Found	0	246,000	0	246,000	0	170,000	0	236,000
	% Deviation	ND	283,000 +15	ND	216,000 -12	ND	116,000 -32	ND	185,000 -22
Iron-55	Added Found	136,000	0	0	92,300	22,200	0	0	177,000
	% Deviation	104,000 -24	ND	* 400	96,000 +4	30,800 +39	ND	ND	161,000 -9
Strontium-89	Added Found	0	0	0	0	0	0	0	0
	% Deviation	ND	ND	ND	* 540	ND	ND	ND	ND
Strontium-90	Added Found	0	0	4,460	5,470	0	0	7,910	6,840
	% Deviation	ND	ND	4,320 -3.1	4,820 -12	ND	ND	* 3,140 -60	6,690 -2.2
Zirconium-95	Added Found	0	3,640	0	3,510	0	1,950	0	2,490
	% Deviation	ND	2,830 -22	ND	3,030 -14	25	1,880 -3.6	ND	2,150 -13
Cadmium-109	Added Found	0	0	1,990	1,660	0	0	4,050	3,860
	% Deviation	* 32	ND	1,960 -1.5	932 -44	* 32	* 13	2,100 -48	2,710 -30
Cesium-137	Added Found	0	1,660	0	1,850	0	3,550	0	6,080
	% Deviation	ND	* 935 -44	ND	1,390 -25	* 0.65	3,100 -13	* 1.6	4,740 -22
Cerium-144	Added Found	0	8,680	0	23,500	0	14,500	0	17,000
	% Deviation	* 3.6	7,770 -10	140	* 7,560 -68	ND	* 5,960 -59	ND	15,500 -8.8
Plutonium-238	Added Found					0	0		0
	% Deviation					ND	ND		ND
Plutonium-239	Added Found					15.6	0		33.9
	% Deviation					9.01 -42	ND		16.1 -53
		July 15			August 15				
		A	B	C	A	B	C		
Manganese-54	Added Found	0	66,600	0	29,500	0	32,400		
	% Deviation	ND	42,400 -36	ND	26,800 -9.2	ND	29,400 -9.3		
Iron-55	Added Found	0	25,700	0	0	29,100	36,000		
	% Deviation	* 410	22,500 -13	ND	* 240	25,000 -14	29,400 -18		
Strontium-89	Added Found	0	3,810	0					
	% Deviation	ND	3,660 -3.9	* 5.46					
Strontium-90	Added Found	0	913	0	484	468	0		
	% Deviation	0.63	884 -3.2	* 3.99	470 -2.9	459 -1.9	0.989		
Zirconium-95	Added Found	0	1,120	0					
	% Deviation	275	1,464 +31	ND					
Cadmium-109	Added Found	0	1,130	0	438	523	0		
	% Deviation	ND	840 -29	* 8.8	102 -77	482 -7.8	ND		
Cesium-137	Added Found	0	29,700	0	3,300	0	4,160		
	% Deviation	2.61	28,900 -2.7	1.68	3,330 +0.91	3.11	4,260 +2.4		
Cerium-144	Added Found	0	5,220	0	1,560	0	1,550		
	% Deviation	ND	4,800 -8	ND	1,440 -7.7	ND	1,420 -8.4		
Plutonium-238	Added Found	0	0	0		0	0		
	% Deviation	ND		* 0.10		1.94	ND		
Plutonium-239	Added Found	0	68.3	0		15.1	8.77		
	% Deviation	ND		ND		6.88 -54	5.59 -36		

See footnotes at end of table.

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Table 18. Continued—Analyses of coded blank and standard samples during 1965

Continued - Analyses of coded blank and standard samples during 1965										
Radionuclide	Sample	Report date								
		September 15				October 15				
		A	B	C	D	A	B	C	D	
Manganese-54	Added Found % Deviation	0 • 380		44,900 44,700 -0.45	35,300 29,500 -16		0 • 198	31,900 33,400 +4.7	0 ND	
Iron-55	Added Found % Deviation	64,500 63,600 -1.4	32,200 32,800 +1.9	0 ND	0 ND		40,400 32,200 -20	0 ND	33,200 30,800 -7.2	
Strontium-89	Added Found % Deviation									
Strontium-90	Added Found % Deviation	217 210 -3.2	206 197 -4.4	0 0.504	0 0.195	0 5.04	302 292 -3.3	0 ND	318 291 -8.6	
Zirconium-95	Added Found % Deviation									
Cadmium-109	Added Found % Deviation	324 308 -4.9	347 324 -6.6	0 ND	0 ND		310 • 253 -18	0 ND	480 314 -35	
Cesium-137	Added Found % Deviation	0 • 1.6	0 ND	377 378 +0.27	371 361 -5.4	432 500 +16	0 • 1.01	358 374 +4.5	0 1.03	
Cerium-144	Added Found % Deviation	0 • 0.96	0 ND	546 525 -3.8	609 554 -9.0	733 710 -3.1	0 • 1.45	691 656 -5.1	0 ND	
Plutonium-238	Added Found % Deviation	0 ND	0 • 0.738	0 ND	0 ND	0 ND	0 ND	0 ND	0 ND	
Plutonium-239	Added Found % Deviation	11.7 6.28 -46	13.1 5.41 -59	0 ND	0 ND	0 ND	20.5 13.1 -36	0 ND	15.2 10.1 -34	
		November 15				December 15				Average percent deviation
		A	B	C	D	A	B	C	D	
Manganese-54	Added Found % Deviation	44,200 5,130 -88	0 ND	23,700 26,400 +11	0 ND	47,400 47,400 +0	0 ND	47,700 48,800 +2.3	0 ND	-16
Iron-55	Added Found % Deviation	0 ND	8,830 7,480 -15	0 • 1,830	12,700 9,560 -25	0 • 180	9,100 6,720 -26	0 ND	11,600 9,280 -20	-8.2
Strontium-89	Added Found % Deviation									-11
Strontium-90	Added Found % Deviation	0 • 0.98	230 214 -7	0 • 0.97	241 200 -17	0 • 0.41	221 210 -5	0 • 2.5	206 204 -0.9	-4.9
Zirconium-95	Added Found % Deviation									-3
Cadmium-109	Added Found % Deviation	0 ND	460 429 -6.7	0 ND	491 358 -27	0 ND	332 338 +1.8	0 ND	396 104 -74	-26
Cesium-137	Added Found % Deviation	694 779 +12	0 ND	453 494 -9.1	0 ND	472 508 +7.6	0 ND	527 609 +16	0 ND	-2.2
Cerium-144	Added Found % Deviation	525 529 +0.8	0 • 0.80	567 555 -2.1	0 • 9.2	590 570 -3.4	0 ND	949 823 -13	0 ND	-6.3
Plutonium-238	Added Found % Deviation	0 • 0.037	0 ND	0	0 0.135	0 • 0.90	0 • 0.092	0 • 0.23	0 0.528	
Plutonium-239	Added Found % Deviation	0 ND	15.8 3.99 -75		17.7 2.57 -85	0 • 0.10	13.1 7.90 -40	0 ND	15.3 9.88 -36	-48

* Figures in table are in units of dpm with percent deviation of "found" from "added" values.

^b Suspect data. Percent standard deviation is not included in average value for radionuclide.

• One standard deviation of counting error is between ± 51 -100 percent.

• One standard deviation of counting error is between ± 20 -50 percent.

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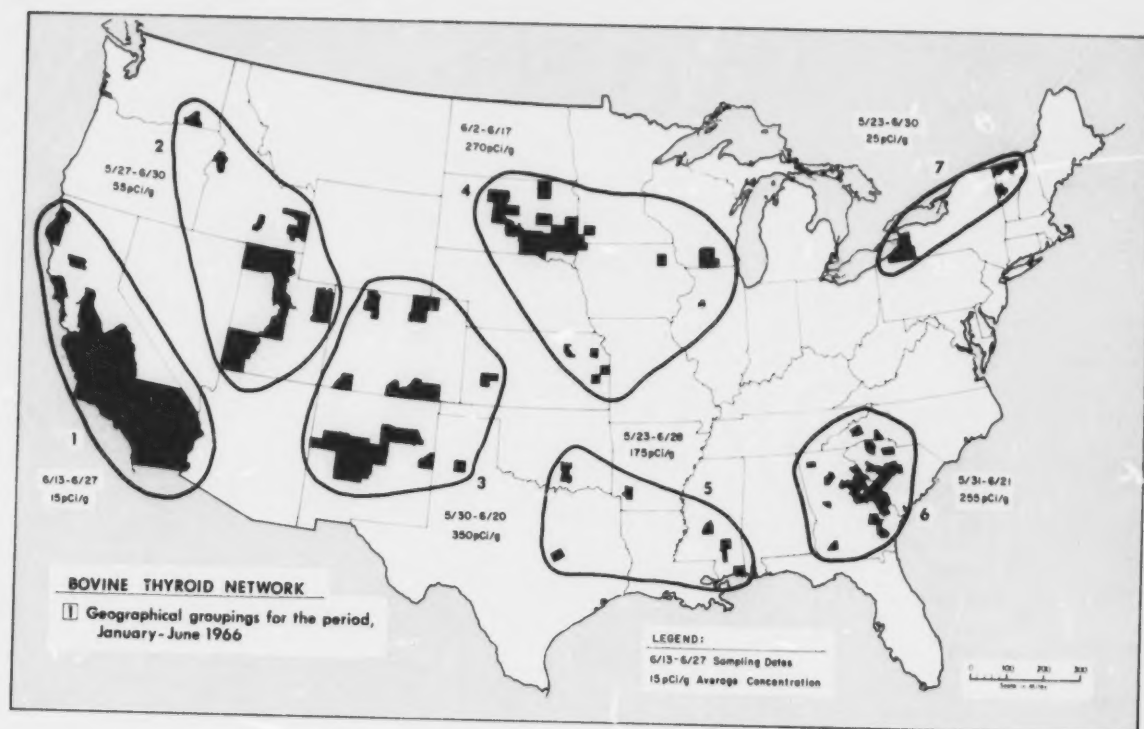


Figure 1. Counties sampled in bovine thyroid network, January-June 1966

Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained

from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

IODINE-131 IN BOVINE THYROIDS, JANUARY-JUNE 1966

National Center for Radiological Health Public Health Service

To supplement its existing environmental surveillance systems, the National Center for Radiological Health established a Bovine Thyroid Network in October 1964 (1). Specimens are collected by the Meat Inspection Division, U.S. Department of Agriculture, and analyzed by gamma-ray spectrometry for iodine-131 content at the Northeastern Radiological Health Laboratory, Winchester, Mass.

The network consists of collection areas (counties shaded in figure 1) located so as to cover, as nearly as possible, areas near major nuclear reactors, spent-fuel reprocessing plants, and nuclear test sites. Details of sampling and analysis have been published earlier (1). For this report, the collection areas sampled during January through June 1966 were grouped on a broad geographical basis as shown in figure 1.

The results for January through June 1966 appear in table 1 and are listed chronologically within the geographical groupings noted in figure 1. The influx of fallout iodine-131 following the mainland China atmospheric nuclear detonation of May 9, 1966, was observed through June 1966, with peak values for individual specimens ranging from 100 to 900 pCi iodine-131/g thyroid in the various geograph-

ical groupings during the early and middle part of June 1966.

To indicate the relative occurrence of iodine-131 in the bovine thyroid for the geographical groupings selected, average observed concentrations (pCi iodine-131/g thyroid) have been calculated for each of the seven groupings. These averages are calculated for the periods of time (shown in figure 1) during which the iodine-131 levels were at their peak or, in the cases where peak values were not observed, for the period during which the counties were sampled after the detonation event. The average values indicate the relative intakes for the bovine populations in each of the geographical groupings. Groupings 1 (California), 2 (Idaho, Utah, and Washington), and 7 (New York and Vermont) reflected low intakes for the bovine populations (15, 55, and 25 pCi/g thyroid, respectively). Considerably higher thyroid concentrations were observed in the remaining four groupings (175-350 pCi/g thyroid).

Recent coverage in Radiological Health Data and Reports:

Period	Issue
January-June 1965	January 1966
July-December 1965	October 1966

REFERENCE

- (1) BARATTA, E. J., E. R. WILLIAMS, and G. MURRAY. Iodine-131 in bovine thyroid, October-December 1964. *Radiol Health Data* 6:569-574 (October 1965).

Table 1. Iodine-131 in bovine thyroids, January-June 1966

Geographical grouping *	Date(s) of slaughter	Counties of origin	Number of samples	pCi iodine-131/g thyroid		
				Average or con- centra- tion	Mini- mum	Maxi- mum
1 California.....	^b 1/3-5/13	[California] *	380	^d ND		
		Fresno (23) * Sacramento (0)				
		Glenn (0) San Benito (2)				
		Humboldt (4) San Bernardino (25)				
		Imperial (1) San Diego (1)				
		Kern (3) San Joaquin (49)				
		Kings (15) San Luis Obispo (5)				
		Los Angeles (91) San Mateo (0)				
		Madera (4) Santa Barbara (7)				
		Marin (2) Sonoma (4)				
		Merced (46) Stanislaus (37)				
		Monterey (26) Tulare (20)				
		Orange (0) Ventura (2)				
		Riverside (13)				
	5/17	Kern.....	1	10		
	5/18	San Bernardino.....	2	ND		
		Los Angeles.....	3	10	ND	17
		San Joaquin.....	4	8	5	13
	5/19	Stanislaus.....	2	4	ND	7
		Fresno.....	2	ND		
		Los Angeles.....	2	5	3	6
	5/20	San Joaquin.....	2	1	ND	2
	5/23	Glenn.....	2	1	ND	2
		Los Angeles.....	1	10		
		Monterey.....	2	30	5	54
		San Joaquin.....	2	15	13	16
		Stanislaus.....	2	8	7	8
	5/24	Los Angeles.....	3	7	ND	20
		Merced.....	2	2	ND	4
		San Bernardino.....	2	ND		
	5/25	San Joaquin.....	2	26	14	38
		Los Angeles.....	2	ND		
	5/27	San Mateo.....	1	ND		
		Kings.....	1	3		
		San Luis Obispo.....	2	8	6	9
	5/31	Tulare.....	1	5		
		Madera.....	2	ND		
		Monterey.....	2	49	3	95
	6/1	Stanislaus.....	2	7	ND	13
		Los Angeles.....	2	8	5	10
		Orange.....	2	1	ND	2
		San Joaquin.....	2	5	ND	3
	6/3	Stanislaus.....	2	5	ND	3
		Los Angeles.....	4	<1	ND	3
	6/6	Monterey.....	2	3	ND	6
		San Joaquin.....	2	2	ND	4
	6/7	Stanislaus.....	2	5	4	5
		Merced.....	2	9	ND	18
	6/8	San Joaquin.....	2	1	ND	2
		Los Angeles.....	2	6	6	6
	6/10	San Bernardino.....	2	4	3	4
		Fresno.....	1	ND		
		Tulare.....	1	3		
	6/13	Ventura.....	2	16	14	17
		Madera.....	2	2	ND	4
		Merced.....	2	24	22	25
	6/14	Monterey.....	2	2	2	2
	6/15	Merced.....	4	4	ND	13
	6/16	Los Angeles.....	2	11	ND	21
		Fresno.....	1	4		
	6/17	Stanislaus.....	1	13		
	6/20	San Bernardino.....	2	12	ND	24
		Monterey.....	2	56	6	106
		Sacramento.....	2	38	ND	75
	6/21	Stanislaus.....	2	14	3	25
		San Joaquin.....	2	24	19	29
	6/22	Stanislaus.....	2	40	34	46
		Los Angeles.....	4	1	ND	3
	6/24	San Bernardino.....	2	5	4	5
		Fresno.....	1	9		
		Kern.....	3	ND		
	6/27	Madera.....	1	6		
		Madera.....	2	22	ND	44
		Sacramento.....	1	28		
	6/28	Stanislaus.....	2	8	5	10
	6/29	Los Angeles.....	2	2	ND	3
	6/30	Los Angeles.....	2	3	ND	5
		Fresno.....	4	7	3	9
2 Idaho, Utah, and Washington.....	^b 1/4-4/22	[Idaho] * [Utah]	47	^d ND		
		Adams (0) * Beaver (0)				
		Bonneville (0) Box Elder (0)				
		Caribou (0) Cache (0)				
		Minidoka (0)				

See footnotes at end of table.

Table 1. Continued—Iodine-131 in bovine thyroids, January-June 1966

Geographical grouping *	Date(s) of slaughter	Counties of origin	Number of samples	pCi iodine-131/g thyroid		
				Average or con- centra- tion	Mini- mum	Maxi- mum
2 Continued.		[Utah] Davis (0) Iron (0) Morgan (0) Salt Lake (0) Sanpete (0) Sevier (0) Unitah (0) Utah (0) Washington (0) Weber (5) [Washington] Walla Walla (42)				
	5/27	Beaver.....	2	13	7	18
		Bonneville.....	1	2		
		Salt Lake.....	2	234	48	460
		Sevier.....	3	7	ND	14
		Utah.....	1	51		
	6/1	Washington.....	1	25		
		Box Elder.....	1	ND		
		Walla Walla.....	1	12	ND	36
	6/7	Weber.....	8	44	ND	129
		Cache.....	4	ND		
		Bonneville.....	1	166		
	6/8	Sanpete.....	3	12	10	15
	6/11	Walla Walla.....	7	38	8	93
	6/13	Adams.....	10	37	16	89
	6/14	Cache.....	4	59	19	114
		Caribou.....	1	125		
		Davis.....	1	6		
		Utah.....	2	48	5	91
	6/18	Weber.....	1	237		
	6/24	Adams.....	10	95	80	119
		Iron.....	1	18		
	6/27	Sevier.....	4	39	5	74
	6/28	[Idaho] f.....	5	74	29	103
		Box Elder.....	3	9	8	10
		Minidoka.....	1	6		
	6/30	Unitah.....	1	55		
		Box Elder.....	1	73		
		Morgan.....	1	233		
		Weber.....	8	72	ND	215
3 Colorado, New Mexico, northwestern Texas, and western Kansas	b 1, 3-5, 3	[Colorado] e Costilla (4) * La Plata (12) Las Animas (4) Routt (4) Weld (0) [New Mexico] Bernalillo (60) Curry (32) San Miguel (8) Socorro (0) Torrance (4) Valencia (12) [Texas] Swisher (0) [Kansas] Finney (0)	140	4 ND		
	5/9	Bernalillo.....	4	6	ND	17
	5/10	Socorro.....	4	5	3	6
	5/16	Valencia.....	4	3	ND	9
	5/17	Valencia.....	4	12	10	15
	5/23	La Plata.....	4	29	7	55
	5/24	Valencia.....	4	17	12	25
		Finney.....	1	4		
	5/30	Costilla.....	4	92	8	327
	5/31	Bernalillo.....	4	200	156	247
	6/6	Valencia.....	4	534	13	762
	6/7	Costilla.....	4	457	38	881
	6/13	Valencia.....	4	563	407	793
	6/14	Valencia.....	4	435	349	493
	6/20	Curry.....	4	137	69	208
	6/21	Curry.....	4	69	7	152
		Weld.....	1	8		
	6/27	Bernalillo.....	4	13	ND	31
	6/28	Valencia.....	4	65	42	97
	6/30	Swisher.....	1	ND		
4 Illinois, Iowa, Kansas, Minnesota, South Dakota, and Wisconsin	b 1, 4-5, 3	[Illinois] e Stark (0) * [Iowa] f Fayette (2) Lyon (11) [Kansas] g Anderson (0) Finney (0) Jefferson (0) Miami (0) Riley (0) [Minnesota] h Rock (11) Murray (0) [South Dakota] i Aurora (0) Beadle (0) Brookings (1) Brown (6) Brule (3) Charles Mix (6) Davison (1) Dewey (10) Douglas (3) Gregory (10) Hanson (5) Hutchinson (10)	216	4 ND		

See footnotes at end of table.

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Table 1. Continued—Iodine-131 in bovine thyroids, January-June 1965

Geographical grouping *	Date(s) of slaughter	Counties of origin	Number of samples	pCi iodine-131/g thyroid		
				Average or con- centra- tion	Mini- mum	Maxi- mum
4 Continued.		[South Dakota] Lake (0) Lincoln (2) Lynman (1) McCook (0) Miner (5) Minnehaha (10) Moody (1)				
		Stanley (10) Sully (5) Turner (17) [Wisconsin] Rock (46) Dane (29) Green (11)				
	5/9	Brown.....	6	3	ND	4
		McCook.....	1	ND		
	5/13	Minnehaha.....	3	ND		
		Dane.....	1	ND		
	5/17	Rock.....	1	ND		
		Dane.....	1	ND		
	5/18	Lyon.....	2	ND		
		Minnehaha.....	1	20		
		Rock.....	1	2		
	5/19	Anderson.....	1	10		
		Miami.....	2	6	5	7
	5/20	Beadle.....	1	21		
		Rock.....	4	<1	ND	3
	5/24	Brookings.....	4	4	2	6
	5/26	Dane.....	6	5	ND	11
	5/27	Green.....	2	8	7	8
	6/1	Lake.....	5	127	72	198
		McCook.....	1	5		
		Minnehaha.....	1	7		
		Murray.....	3	141	51	255
	6/2	Miner.....	2	2	2	2
		Stark.....	2	166	56	276
	6/6	Jefferson.....	11	413	312	558
	6/9	Aurora.....	1	212		
	6/10	Dane.....	6	237	4	638
	6/14	Aurora.....	2	19	13	24
		Brookings.....	3	235	134	286
		Minnehaha.....	2	206	ND	412
	6/16	Dane.....	3	531	184	814
	6/17	Riley.....	2	48	43	53
	6/22	Riley.....	3	40	30	49
	6/23	Dane.....	1	9		
		Rock.....	1	5		
	6/29	Dane.....	1	12		
	6/30	Rock.....	5	25	ND	48
		Rock.....	2	20	15	25
5 Arkansas, Mississippi, Oklahoma and eastern Texas	5/9-5/16 *	[Arkansas] * Hempstead (2) * [Mississippi] Forrest (12) Jackson (0) Jones (0) Rankin (0)	23	ND		
		[Oklahoma] Pontotoc (6) Johnston (2) [Texas] Falls (1)				
	5/23	Forrest.....	6	18	3	50
	6/1	Jackson.....	5	485	189	883
		Rankin.....	1	402		
	6/7	Forrest.....	6	206	110	327
	6/16	Jackson.....	6	151	95	251
	6/21	Jones.....	5	73	ND	145
	6/28	Forrest.....	5	85	69	101
6 Georgia, North Carolina, and South Carolina	1/5-5/16 *	[Georgia] * Bulloch (1) * Burke (0) DeKalb (0) Elbert (0) Gordon (1) Greene (0) Gwinnett (0) Hancock (1) Jenkins (1) Jefferson (3) Lincoln (2) McDuffie (2) Mitchell (2) Morgan (2) Richmond (0) Screven (1) Taliaferro (1) Tattnell (1)	38	ND		
		Toombs (3) Upson (1) Washington (5) Warren (4) Wayne (0) Wilkes (3) [North Carolina] Buncombe (0) Cleveland (2) [South Carolina] Aiken (0) Chester (0) Greenwood (0) Lexington (0) Richland (2) Saluda (0) Spartanburg (0)				
	5/17	Cleveland.....	3	6	2	11
		Richmond.....	1	ND		
		Screven.....	3	ND		
		Warren.....	1	ND		

See footnotes at end of table.

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Table 1. Continued—Iodine-131 in bovine thyroids, January-June 1966

Geographical grouping *	Date(s) of slaughter	Counties of origin	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
6 Continued.	5/24	Chester.....	3	34	2	70
		Greene.....	1	150		
		Greenwood.....	2	89	36	141
		Morgan.....	2	ND		
	5/30	Screven.....	1	5		
		Wilkes.....	1	150		
		Jefferson.....	1	8		
		Morgan.....	1	ND		
	5/31	Aiken.....	1	145		
		Cleveland.....	1	48		
		Greene.....	1	149		
		Saluda.....	1	624		
	6/13	Screven.....	2	627	524	729
		Wilkes.....	2	582	349	815
		Greene.....	4	188	44	360
		Lexington.....	2	223	145	301
	6/16	Spartanburg.....	4	292	171	590
		Elbert.....	1	243		
		Gwinnett.....	1	702		
		Warren.....	1	160		
	6/17	Wilkes.....	2	296	244	348
		Buncombe.....	3	123	36	285
		Spartanburg.....	2	39	24	54
		Greene.....	2	130	109	151
	6/21	Burke.....	2	85	59	131
		Lexington.....	1	167		
		Saluda.....	1	190		
		Burke.....	1	66		
	6/22	DeKalb.....	1	59		
		Wayne.....	1	39		
		Wayne.....	1	276		
		Burke.....	1	2		
	6/27	Greenwood.....	2	39	38	39
		Screven.....	1	280		
	6/28	Greene.....	2	107	91	123
		Saluda.....	2	84	44	124
		Warren.....	1	118		
		Wilkes.....	1	89		
	6/30	Elbert.....	1	56		
		Taliaferro.....	1	36		
7 New York and Vermont	1-6-5-21 ^b	[New York] ^c	281	^d ND		
		Cattaraugus (62) *				
		Chautauqua (10)				
		Erie (26) Franklin (173)				
	5/23	[Vermont] Grande Isle (0)				
		Addison (8) Orleans (2)				
		Franklin.....	10	11	ND	48
		Chautauqua.....	10	63	ND	261
	5/31	Franklin.....	9	ND		
		Chautauqua.....	10	24	ND	115
		Erie.....	3	45	13	88
		Franklin.....	5	53	2	120
	6/6	Chautauqua.....	10	39	ND	95
		Erie.....	7	33	ND	67
		Chautauqua.....	3	54	ND	118
		Franklin.....	10	ND		
	6/16	Chautauqua.....	7	33	ND	89
		Erie.....	6	49	ND	131
		Franklin.....	2	59	24	94
		Chautauqua.....	10	50	4	83
	6/22	Franklin.....	7	14	ND	26
		Grande Isle.....	1	13		
		Erie.....	4	28	7	45
		Chautauqua.....	10	20	8	39
	6/29	Franklin.....	10	ND		
		Franklin.....	10	ND		
		Erie.....	5	14	4	20
		Erie.....	5	14	4	20

* Geographical areas as designated in figure 1, encompassing those counties that were sampled in the States indicated.

^b Samples were not collected on all dates during this period, but the interval includes several sampling dates.

^c Brackets give State and are followed by counties sampled during the period indicated or on some other date during January-June 1966.

^d The results for this period were for the most part not detectable. Some positive results were obtained, but represented barely detectable amounts of iodine-131 in the bovine thyroid. In general, these positive results were 2-7 pCi/g thyroid and randomly scattered over the time period and counties indicated.

* Numbers in parentheses represent the number of samples collected from each county during the interval indicated. These may have been collected over several dates during the period or on only one date. (0) indicates that the county was not sampled during the interval given but was sampled on another date during January-June 1966.

^e The State is given, but the exact county is unknown. The county is most likely one of those listed under the time interval 1/4-4/23.

ND, not detectable; the two standard deviation counting error was greater than or equal to the concentration observed. For the counting system utilized and these very low concentrations the two standard deviation counting errors were generally 1-3 pCi/g thyroid.

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a

nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.¹

Summaries of the environmental radioactivity data follow for the Oak Ridge Gaseous Diffusion Plant, Paducah Plant, and the Portsmouth Area Gaseous Diffusion Plant.

¹ Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

1. Oak Ridge Area January-June 1966 :

*Union Carbide Nuclear Company
Oak Ridge, Tennessee*

Oak Ridge area is a complex made up primarily of the Y-12 Plant, the Oak Ridge National Laboratory (ORNL), and the Oak Ridge Gaseous Diffusion Plant (ORGDP).

Radioactive waste materials arising from the operation of atomic energy installations in the Oak Ridge area are collected, treated, and disposed of according to their physical states. Solid wastes are buried in a Conasauga shale formation which has a marked ability to fix radioactive materials by an ion-exchange mechanism. Liquid wastes which contain long-lived fission products are confined in storage tanks or are released to trenches located in the Conasauga shale formation. Low-level liquid wastes are discharged, after preliminary treatment, to the surface streams. Air that may become contaminated by radioactive materials is exhausted to the atmosphere from several tall stacks after

treatment by means of filters, scrubbers, and/or precipitators.

Air Monitoring

Atmospheric contamination by radioactive materials occurring in the general environment of east Tennessee is monitored by two systems of monitoring stations. One system consists of eight stations which encircle the plant areas (figure 1) and provide data for evaluating the impact of all Oak Ridge operations on the immediate environment. A second system consists of seven stations encircling the Oak Ridge area at distances of from 12 to 75 miles (figure 2). This system provides data to aid in evaluating local conditions and to assist in determining the spread or dispersal of contamination should a major incident occur.

Sampling for radioactive particulates is carried out by passing air continuously through a filter paper. Average concentrations are presented in table 1. Airborne radioactive iodine is monitored in the immediate environment of the plant areas by passing air through a cartridge containing activated charcoal.

² Summarized from Environmental Levels of Radioactivity for the Oak Ridge Area, compiled by the Health Physics and Safety Section of the Health Physics Division, Oak Ridge National Laboratory.

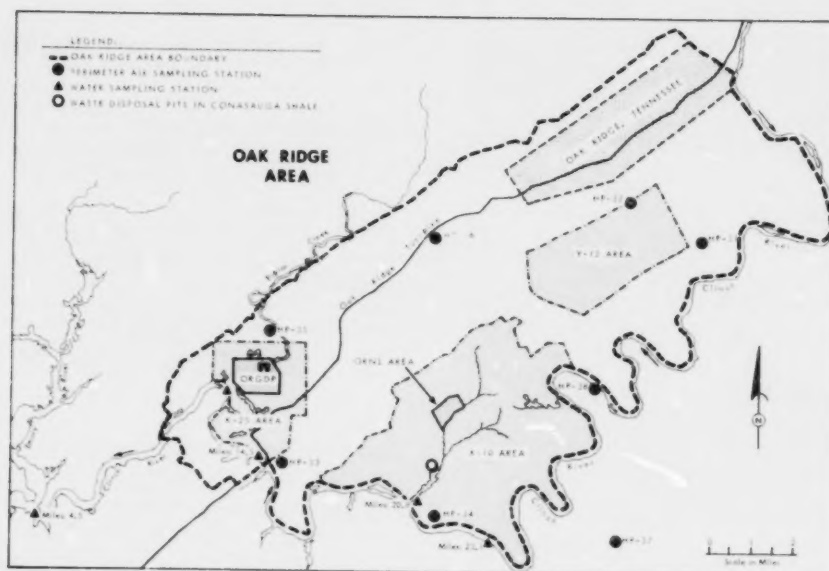


Figure 1. Oak Ridge Area environmental sampling locations

Table 1. Long-lived gross beta and alpha radioactivity in particulates in air Oak Ridge area, January-June 1966

Station number	Number of samples	Beta activity		Alpha activity	
		Average concentration (pCi/m ³)	Percent of AEC standard	Average concentration (pCi/m ³)	Percent of AEC standard
Perimeter stations ^a					
HP-31	26	0.12	0.12	0.006	0.30
HP-32	26	0.11	0.11	0.006	0.30
HP-33	26	0.09	0.09	0.005	0.25
HP-34	26	0.10	0.10	0.006	0.30
HP-35	26	0.12	0.12	0.006	0.30
HP-36	178	0.18	0.18	0.014	0.70
HP-37	26	0.08	0.08	0.004	0.20
HP-38	26	0.13	0.13	0.006	0.30
Average		0.12	0.12	0.007	0.35
Remote stations ^b					
HP-51	26	0.11	0.11	0.003	0.15
HP-52	26	0.12	0.12	0.004	0.20
HP-53	26	0.12	0.12	0.004	0.20
HP-54	26	0.11	0.11	0.004	0.20
HP-55	26	0.11	0.11	0.003	0.15
HP-56	25	0.12	0.12	0.004	0.20
HP-57	26	0.11	0.11	0.003	0.15
HP-58	25	0.12	0.12	0.004	0.20
Average		0.12	0.12	0.004	0.20

^a See figure 1.
^b See figure 2.

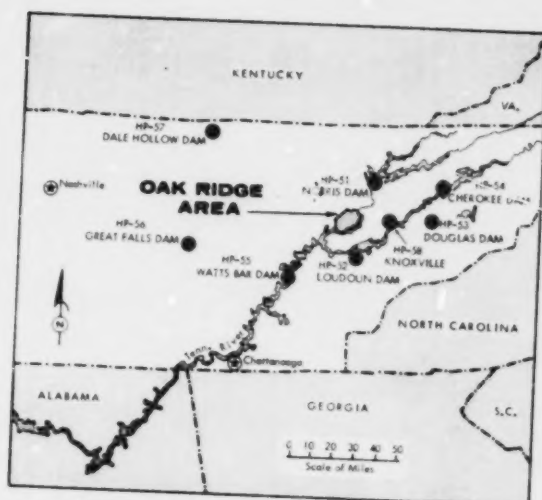


Figure 2. Remote air monitoring stations Oak Ridge Area

Milk monitoring

Raw milk is monitored for iodine-131 and strontium-90 by the collection and analysis of samples from 12 sampling stations located within a radius of 50 miles of ORNL. Samples are collected weekly at each of eight stations located on the fringe of the Oak Ridge area. Four stations, located more remotely with respect to the Oak Ridge operations, are sampled at a rate of one station each week. The purpose of the milk sampling program is twofold: first, samples collected in the immediate vicinity of the Oak Ridge area provide data by which one may evaluate possible exposure to the neighboring population resulting from waste releases from Oak Ridge operations; second, samples collected at the more remote stations provide background data which are essential in establishing the proper index for the evaluation of data obtained from local samples. The concentrations of iodine-131 and strontium-90 detected in raw milk samples during the period are given in table 2.

Water monitoring

Large-volume, low-level liquid wastes originating at ORNL are discharged, after some preliminary treatment, into the Tennessee River system by way of White Oak Creek and the

Table 2. Radionuclides in raw milk, Oak Ridge area January-June 1966

Radionuclide and location	Concentration, pCi/liter		
	Maximum	Minimum *	Average
Iodine-131			
Immediate environs.....	124	<10	10
Remote environs.....	30	<10	6.3
Strontium-90			
Immediate environs.....	64	7.7	25
Remote environs.....	39	16	23

* The minimum detectable concentrations of iodine-131 and strontium-90 in milk are 10 pCi/liter and 2 pCi/liter, respectively. In averaging, one-half of the minimum detectable concentration was used for all samples showing an activity less than this concentration.

Clinch River. Liquid wastes originating at the ORGDP and Y-12 Plant are discharged to Poplar Creek and thence to the Clinch River. Releases are controlled so that resulting average concentrations in the Clinch River comply with AEC standards. The radioactivity concentration from White Oak Creek is measured, and concentration values for the Clinch River are calculated on the basis of the dilution provided by the river.

Water samples are taken at a number of locations in the Clinch River, beginning at a point above the entry of wastes into the river and ending at Center's Ferry near Kingston, Tenn. Stream-gauging operations are carried on continuously to obtain dilution factors for calculating the probable concentrations of wastes in the river.

Samples are analyzed for the long-lived beta emitters, uranium, and the transuranic alpha emitters.

Analyses are made of the effluent for the long-lived radionuclides only, since cooling time and hold-up time in the waste effluent system are such that short-lived radionuclides are normally not present. The average concentrations of major radionuclides in the Clinch River are given in table 3 for the period from January through June 1966.

Gamma measurements

External gamma radiation levels are measured monthly at a number of locations in the Oak Ridge area. Measurements are taken with a Geiger-Mueller tube at a distance of 3 feet above the ground. The results are shown in table 4 in terms of mR/hr.

Table 3. Concentrations of major radionuclides in the Clinch River, January-June 1966

Radionuclide	Average concentration, pCi/liter		
	Mile 23.1 ^a (upstream)	Mile 20.8 ^{a,b} (outfall)	Mile 4.5 ^a (downstream)
Strontium-90	1.3	1.5	2.9
Cesium-144	0.4	<0.1	1.0
Cesium-137	0.5	0.9	1.3
Ruthenium-106	1.1	11.0	5.9
Cobalt-60	ND	5.3	6.1
Zirconium-niobium-95	ND	<0.1	<0.1
Gross beta	3.3	110	17

^a The location on Clinch River is given in terms of the distance upstream from the Tennessee River (figure 1).

^b The concentrations at mile 20.8 are not measured directly but the values are calculated based on the levels of waste released and the dilution afforded by the river.

ND, none was detected.

Table 4. External gamma radiation levels, Oak Ridge area January-June 1966

Location	Average dose rates (mR/hr)
Solway Gate	0.012
Y-12, East Portal	0.011
Newcomb Road	0.011
Gallagher Gate	0.013
White Wing Gate	0.012
Average	0.012

Discussion of data

The average air-contamination levels for gross beta particle activity, as shown by the continuous air monitoring filter data, for both the immediate and remote environs of the plants (figures 1 and 2) were 0.12 percent of the AEC standard for populations in the neighborhood of a controlled area. These values are approximately one-third higher than those for the last half of 1965. The higher levels may be attributed to an increase in fallout from weapons testing.

The average air-contamination levels for gross alpha particle activity, as shown by the continuous air monitoring filter data, for the immediate and remote environs of the plants were 0.35 percent and 0.25 percent, respectively, of the AEC standard for natural uranium for application to populations in the neighborhood of a controlled area.

The average concentration of iodine-131 in air in the immediate environs of the plants was 0.016 pCi/m³. This is approximately 0.016 percent of the AEC standard for populations in the neighborhood of a controlled area.

The average concentrations of iodine-131 in raw milk in the immediate and remote environs of the Oak Ridge area were 10 pCi/liter and 6.3 pCi/liter, respectively. The maximum concentration observed, 124 pCi/liter, occurred on May 25, 1966, approximately 3 days after the arrival in the Oak Ridge area of fallout containing fresh fission products. The average values fall within the limits of FRC Range I if the average intake per individual is assumed to be 1 liter of milk per day.

The average concentrations of strontium-90 in raw milk in the immediate and remote environs of the controlled area were 25 pCi/liter and 23 pCi/liter, respectively. These levels fall within FRC Range II for transient rates of daily intake of strontium-90 for application to the average of suitable samples of an exposed population.

The calculated average concentration of radioactivity in the Clinch River at mile 20.8 (the point of entry of most of the wastes) and the measured average concentration at mile 4.5 (near Kingston, Tenn.) were 110 pCi/liter and 17 pCi/liter, respectively. These values are 2.8 percent and 1.1 percent of the weighted average AEC standards. The average concentration of transuranic alpha emitters in the Clinch River at mile 20.8 was 0.12 pCi/liter, which is approximately 0.003 percent of the weighted average AEC standard.

The average activity of natural uranium materials in the Clinch River, reflecting the effects of all Oak Ridge plants, was <0.01 percent of the AEC standard for uranium.

The average external gamma radiation measured in the town of Oak Ridge and at the perimeter of the Oak Ridge area was 0.012 mR/hr, which is approximately the same as that level measured during the period prior to Oak Ridge operations.

Conclusion

Surveillance of the radioactivity in the Oak Ridge environs indicated that the major part of the radioactivity detected continues to be the result of fallout from weapons testing. While some low-level radioactivity is being released to the environment from plant operations, the resulting concentrations in both the atmosphere and surface streams of the Oak

Ridge environment are well below established AEC standards for the neighboring population.

Recent coverage in *Radiological Health Data and Reports*:

Period
January-June 1964
July-December 1964
January-June 1965
July-December 1965

Issue
January 1965
July 1965
January 1966
September 1966

2. Paducah Plant January-June 1966^{*}

*Union Carbide Corporation
Paducah, Kentucky*

The Paducah Plant is a Government-owned gaseous diffusion plant operated by the Nuclear Division of the Union Carbide Corporation for the Atomic Energy Commission. The diffusion plant processes large quantities of relatively pure uranium compounds. A former source of diffusion plant feed, the uranium hexafluoride manufacturing plant, was placed on standby in June 1964. Parts of the associated uranium metal foundry are operated infrequently as the need arises; otherwise, it is also on standby status. A decontamination and uranium recovery facility operates to prepare equipment for repair and to recover impure or scrap uranium materials. Depleted uranium metal is fabricated into shields, weights, or ballasts, or other shapes on a non-routine basis. The major sources of external penetrating radiation are the daughter products of uranium, thorium-234 and protactinium-234, which may be concentrated by uranium recovery processes or by uranium hexafluoride vaporization. The element uranium can be a physiological hazard only if allowed to enter the body. The chemical toxicity of the uranium processed at the Paducah Plant overshadows any probable biological effects of radiation from this element,

thus making it comparable as a physiological hazard to lead, mercury, or other well-known heavy metals.

Because of the necessity for health protection in process areas, the high intrinsic value of uranium, and the desire to maintain a wholesome relationship with neighboring communities and individuals, the Paducah Plant provides confinement and recovery to the greatest extent feasible.

An environmental monitoring system checks the effectiveness of the confinement and recovery systems of the plant. The environmental monitoring program provides for continuously sampling the air at four stations around the plant-perimeter fence, and at five stations located approximately 1 mile outside this fence (figure 3). Big Bayou Creek water is sampled continuously, and grab samples are collected at five locations in the Ohio River. In addition, gamma-radiation readings are taken each month at each of the air-sampling stations with a Geiger-Mueller-type meter at a distance of 3 feet above ground level.

Basic standards

The standards observed at the Paducah Plant for exposure to radiation and radioactive materials, both for the in-plant work environment of employees and for offsite exposure of the general population, are those listed in the AEC manual.

The standards specify that the radiation or radioactive materials outside a controlled area, which have resulted from operations within that controlled area, shall be such that it is improbable that any individual may receive a dose of external radiation greater than 0.5 rem in any year and that the average exposure of a suitable population sample may not exceed one-third of this dose. To meet this standard, the average concentration of radionuclides in air or water outside a controlled area should not exceed one-tenth of the maximum permitted for occupational exposure of 168 hours per week. For the purposes of such control, the concentrations of such radionuclides in air or water may be averaged over periods of time up to 1 year.

^{*} Summarized from "Environmental Concentrations of Radioactive Materials near the Paducah Plant—Report for the First Half of 1966."

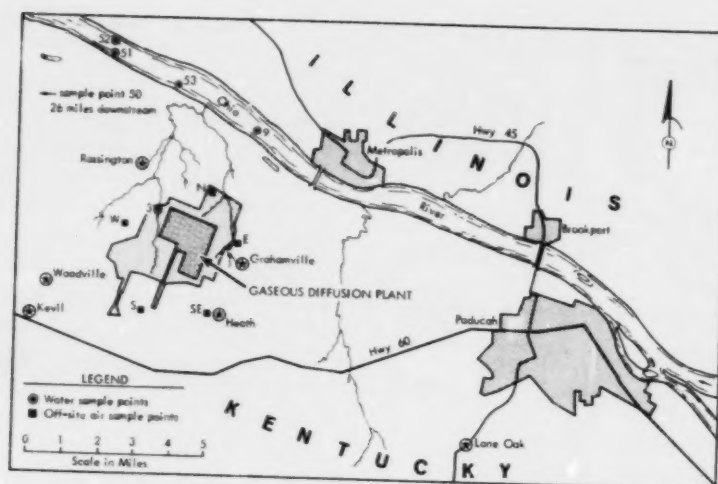


Figure 3. Sampling locations, Paducah Plant

Discussion

Data summarizing the environmental concentrations of radioactive materials in air and water and the gamma radiation levels in the vicinity of the Paducah Gaseous Diffusion Plant are presented in tables 5 through 8.

Air samples were collected continuously at each of the four stations at the plant-perimeter

fence and at five stations at about 1 mile outside the plant. Air is filtered at 0.3 cfm through 2-inch-diameter membrane filters which are replaced weekly and counted for alpha and beta radioactivity.

The average alpha particle count—interpreted as uranium, the most likely source of activity—

Table 5. Uranium radioactivity in outdoor air samples Paducah Plant, January-June 1966

Sample location *	Number of samples	Uranium alpha radioactivity ^b (pCi/m ³)			Mean as percent of concentration limit ^d
		Maximum	Minimum ^a	Mean	
At plant perimeter fence					
North	26	0.08	<0.02	<0.02	<1
East	26	0.07	<0.02	<0.02	<1
South	26	0.02	<0.02	<0.02	<1
West	26	0.05	<0.02	<0.02	<1
Totals	104	0.08	<0.02	<0.02	<1
About 1 mile outside plant perimeter fence					
North	26	0.09	<0.02	<0.02	<1
East	26	0.05	<0.02	<0.02	<1
South	25	0.05	<0.02	<0.02	<1
West	26	0.08	<0.02	<0.02	<1
Southeast	26	0.10	<0.02	<0.02	<1
Totals	129	0.10	<0.02	<0.02	<1

* See map, figure 3.

^b As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57×10^4 alpha dis/sec.

^c The minimum detectable concentration of uranium in air is 0.02 pCi/m³.

^d The concentration limit for natural uranium in air released to the environs beyond a controlled area is 2 pCi/m³.

Table 6. Beta radioactivity in outdoor air samples Paducah Plant, January-June 1966

Sample location *	Number of samples	Beta radioactivity (pCi/m ³)			Mean as percent of concentration limit ^c
		Maximum	Minimum ^b	Mean	
At plant perimeter fence					
North	26	0.98	<0.1	0.17	0.02
East	26	1.2	<0.1	0.19	0.02
South	26	0.40	<0.1	0.13	0.01
West	26	0.50	<0.1	0.16	0.02
Totals	104	1.2	<0.1	0.17	0.02
About 1 mile outside plant perimeter fence					
North	26	0.54	<0.1	0.16	0.02
East	26	0.35	<0.1	0.14	0.01
South	25	0.63	<0.1	0.15	0.02
West	26	0.35	<0.1	0.16	0.02
Southeast	26	1.9	<0.1	0.23	0.02
Totals	129	1.9	<0.1	0.17	0.02

* See map, figure 3.

^b The minimum detectable amount of beta emitters in air is 0.1 pCi/m³.
^c The concentration limit applicable to this table is 1,000 pCi/m³, which is the concentration limit of thorium-234, the daughter product of uranium-238. Insignificant amounts of other daughters are present in freshly refined uranium.

**Table 7. Concentrations of uranium in water
Paducah Plant, January-June 1966**

Sample location ^a	Number of samples	Uranium concentration ^b (pCi/liter)			Mean as percent of concentration limit ^d
		Maximum	Minimum ^c	Mean	
Big Bayou Creek	26	26	<1	9	0.05
Ohio River	6	1	<1	<1	<0.01
Composite of 50, 51, 52, and 53	6	1	<1	<1	<0.01

^a See map, figure 3.

^b As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57×10^4 dis/sec.

^c The minimum detectable uranium in water is 1 pCi/liter.

^d The concentration limit for natural uranium in water beyond a controlled area is 20,000 pCi/liter.

**Table 8. Beta radioactivity in water
Paducah Plant, January-June 1966**

Sample location ^a	Number of samples	Beta radioactivity (pCi/liter)			Mean as percent of concentration limit ^c
		Maximum	Minimum ^b	Mean	
Big Bayou Creek	26	600	<100	100	0.5
Ohio River	6	100	<100	100	0.5
Composite of 50, 51, 52, and 53	6	500	<100	200	1

^a See map, figure 3.

^b The minimum detectable amount of beta emitters in water is 100 pCi/liter.

^c The concentration limit for the immediate daughter products of uranium in water released to the environs is 20,000 pCi/liter.

of the 233 air samples collected during the first half of 1966 was less than 1 percent of the concentration limit set for individuals residing in the vicinity of a controlled area. The mean beta-particle count of the same samples was 0.02 percent of the concentration limit.

The average uranium analysis of weekly water samples collected continuously from the Big Bayou during the first half of 1966 was 0.05 percent of the concentration limit for water beyond a controlled area. The results of the uranium analyses for each of the six grab samples collected at monthly intervals from the Ohio River below the plant were equal to or less than 0.01 percent of the concentration limit.

The concentration of beta emitters in the Big Bayou averaged 0.5 percent of the concentration limit for the decay products of uranium-238 during the first half of 1966. The beta-particle activity of the Ohio River averaged 1 percent of the concentration limit for uranium-238 decay products during the period.

External gamma radiation in the vicinity of the Paducah Plant averaged 0.02 mR/hour at all sampling stations for the first half of 1966.

3. Portsmouth Area Gaseous Diffusion Plant January-June 1966 ^a

*Goodyear Atomic Corporation
Piketon, Ohio*

The separation of uranium isotopes by the gaseous diffusion process presents control problems similar to any chemical process using toxic solvents and extraction solutions. Natural uranium and thorium-234 are the most likely radionuclides to be released to the environment by the Portsmouth Area Gaseous Diffusion Plant. Since natural uranium is an alpha emitter, and thorium-234 is a beta-gamma emitter, environmental monitoring is conducted for evidence of alpha and beta-gamma emitters to test the effectiveness of plant controls.

Air samples are generally collected monthly at 21 sites located from 1 to 6 miles from the plant as shown in figure 4. Monthly water samples are collected at 13 stations within 5 miles of the plant.

Average airborne alpha activity showed a reduction during the first half of 1966 when compared with the final period of 1965. The alpha activity dropped from 9.7 to 7.3 percent of the concentration standard. The airborne beta-gamma activity, however, increased slightly over the previous 6-month average. The increase, from 0.01 to 0.03 percent of the beta-gamma concentration standard, is attributed to statistical counting error.

^a Data summarized from B. Kalmon and S. H. Hulett: "Environmental Radiation Levels and Concentrations--First Half 1966," GAT 528 (September 1, 1966).

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January-June 1964	February 1965
1964	July 1965
January-June 1965	January 1966
July-December and calendar year 1965	July 1966

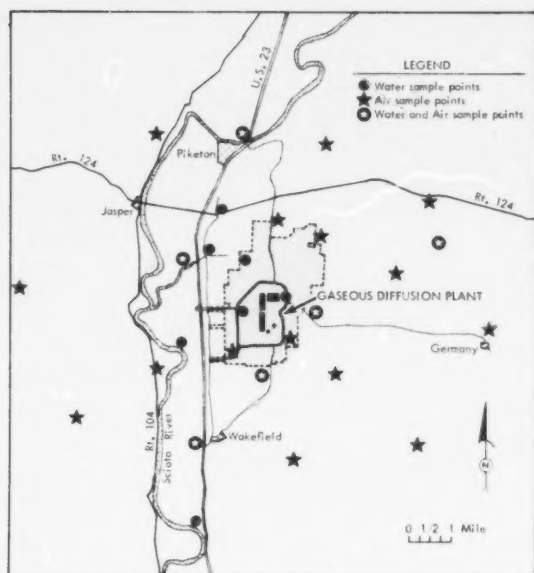


Figure 4. Sampling locations, Portsmouth Area Gaseous Diffusion Plant

During the period January-June 1966, both the average alpha and beta-gamma radioactivities in water samples decreased to levels below those for the previous period. The average radioactivity monitored in water amounted to 0.07 percent of the AEC concentration standards for both alpha and beta-gamma emitters.

Annual background exposure rates continued to decline during the first half of 1966, decreasing from 30.0 percent to 17.7 percent of the exposure standards in the past year. In the calculations it is assumed that all of the exposure rates are attributable to plant operations. As in the past, the offsite and onsite patterns are very much alike in form and intensity with no significant differences between the average values. From the onsite and offsite intensities and the continuing decline in exposure rates which followed the moratorium in nuclear testing activities, it is evident that the plant operations have not added appreciably to the general background radiation.

Average alpha and beta-gamma radioactivity in air and water are summarized in table 9. The external gamma-ray levels, measured at the air sampling locations shown in figure 4, are also summarized in table 9. The overall

average concentrations and background exposure rates for the first half of 1966, along with the values for the first and second half of 1965 and calendar year 1965, are presented in table 10 as percents of standards.

Table 9. Environmental radioactivity
Portsmouth Plant, January-June 1966

Type of monitoring	Number of samples	Maximum	Minimum	Average	Average as a percent of AEC standard *
Air					
Alpha radioactivity (pCi/m ³)	124	1.0	<0.1	0.1	7.3
Beta-gamma radioactivity (pCi/m ³)	124	3.3	<0.1	0.3	0.03
Water					
Alpha radioactivity (pCi/liter)	72	171.0	<0.5	14.0	0.07
Beta-gamma radioactivity (pCi/liter)	72	238.0	<14.0	13.9	0.07
Background exposure ^b (mrad/hr)	126	0.023	<0.009	0.015	17.7

* The applicable AEC exposure standards are as follows:

Air (alpha) 2 pCi/m³
Air (beta-gamma) 1,000 pCi/m³
Water (alpha) 20,000 pCi/liter
Water (beta-gamma) 20,000 pCi/liter

External beta-gamma 500 mrad/yr (approx. 0.06 mrad/hr)
^b Measurements were made with an open-shield Geiger-Mueller tube 1 foot above ground. The 3-foot rate (not shown) was experimentally determined to average two-thirds of the 1-foot rate and was used to determine the percent of the concentration standard.

Table 10. Comparison of average concentrations
Portsmouth Plant, 1965 and January-June 1966

Type of monitoring	Percent of AEC concentration or exposure standard *			
	1966		1965	
	First half	Second half	First half	Calendar year
Air				
Alpha radioactivity	7.3	16.1	9.7	13.8
Beta-gamma radioactivity	0.03	0.05	0.01	0.03
Water				
Alpha radioactivity	0.07	0.19	0.45	0.30
Beta-gamma radioactivity	0.07	0.49	0.18	0.32
Background exposure extrapolated to 3 feet above ground level	17.7	30.0	24.1	27.7

* See footnote (a), table 9.

Recent coverage in *Radiological Health Data and Reports*:

Period
January-June 1964
1964
January-June 1965
July-December 1965

Issue
February 1965
July 1965
January 1966
July 1966

Section V. Technical Notes

REPORTED NUCLEAR DETONATIONS, DECEMBER 1966

During December 1966, three U.S. nuclear tests were reported and one Chinese mainland nuclear test was detected. Project Sterling, a 350-ton nuclear detonation experiment, was conducted on December 3, 1966. The detonation occurred some 2,700 feet underground in the Tatum Salt Dome near Hattiesburg, Mississippi. The experiment was designed to determine the extent of decoupling (a reduction of ground shock and other seismic signals) in a cavity formed by a previous nuclear detonation.

A nuclear test of low yield (less than 20 kilotons TNT equivalent) was conducted underground on December 13, 1966, by the U.S. Atomic Energy Commission at its Nevada Test Site. A second nuclear test of intermediate yield

(200 kilotons to one megaton TNT equivalent) was conducted underground on December 20, 1966.

The U.S. Atomic Energy Commission announced detection of another nuclear test on the Chinese mainland in the atmosphere at their test site near Lop Nor on December 28, 1966. The yield was a few hundred kilotons TNT equivalent.

Preliminary analysis indicates that the fifth Chinese mainland nuclear test contained uranium-238 and enriched uranium-235 as the fissionable materials. This explosion, like the third Chinese mainland test, involved thermonuclear material. There are no indications that plutonium was used in the device.

SYNOPSIS

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

A SUMMARY OF EXPOSURES TO THE OFFSITE POPULATION AS A RESULT OF NUCLEAR REACTOR TESTS CONDUCTED AT THE NUCLEAR ROCKET DEVELOPMENT STATION DURING 1965. D. T. Oakley. *Radiological Health Data and Reports*, Vol. 8, January 1967, pp. 1-4.

A summary of whole-body and thyroid exposures resulting from five nuclear reactor experiments conducted at the Nuclear Rocket Development Station during 1965 is presented. The exposures are compared with protection standards and it is shown that the exposures are small compared to the standards.

KEY WORDS: exposure-external, exposure-internal, iodine-131, iodine-133, milk, nuclear reactor tests, thyroid.

☆U.S. Government Printing Office: 1967-252-804/6

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 8, Number 2 February 1967

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the National Center for Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators. These are subject to review by a Board of Editorial Advisors with representatives from the following Federal agencies:

Department of Defense
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Atomic Energy Commission

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National Center for Radiological Health, PHS

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<i>Richard D. Grundy</i>	

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RADIOLOGICAL HEALTH DATA AND REPORTS

Published under the direction of

James G. Terrill, Jr., Director and
Dr. Raymond T. Moore, Deputy Director
National Center for Radiological Health

by the Standards and Intelligence Branch
National Center for Radiological Health
Donald L. Snow, Chief

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Address correspondence to the Managing Editor, *Radiological Health Data and Reports*, National Center for Radiological Health, Public Health Service, Rockville, Maryland 20852.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • National Center for Radiological Health

RADIONUCLIDE LEVELS IN MILK, TOTAL DIET, AND HUMAN BONE COMPARED TO FEDERAL RADIATION COUNCIL ESTIMATES, 1965, AND 1966 ESTIMATES

*Standards and Intelligence Branch
National Center for Radiological Health¹
Public Health Service*

Estimates of the levels of fallout radionuclides in environmental media and in human bone expected from 1963 through 1965 have been made by the Federal Radiation Council. The 1965 observed values are compared with the FRC predictions and 1966 levels are estimated using the approach proposed by the Federal Radiation Council. The observed radionuclide levels are in agreement with the prediction made by the Federal Radiation Council. The observed levels and the predicted levels of radioactivity in food over the next several years are too small to justify protective action to limit the dietary intake of radionuclides.

The Federal Radiation Council (FRC) has made estimates of the levels of fallout radionuclides in environmental media and in human bone expected from 1963 through 1965 from atmospheric testing of nuclear weapons conducted through 1962 (1,2). Observed values for 1963 and 1964, based on surveillance measurements, were presented earlier and compared to these predictions (3). Discussion was centered on those ingested fallout radionuclides most significantly contributing to the internal radiation dose to man: strontium-89, strontium-90, iodine-131, and cesium-137. This paper compares the 1965 observed values with the FRC predictions and, using the approach taken by FRC, estimates 1966 levels.

Milk

While total diet measurements yield the most direct estimate of radionuclide intakes, specific indicator foods are also important. The single food item most often used as an indicator of the population's intake of radionuclides from the environment is milk. At the same time, milk is often the most rapid food vector by which man can be exposed. Milk contains most of

the radionuclides occurring in the environment which have been identified as biologically significant, and is consumed by a large segment of the U.S. population.

The Public Health Service's Pasteurized Milk Network (PMN) monitors radionuclide concentrations at 63 sampling locations in selected U.S. municipalities and is the primary source of data for radioactivity in milk used in this article (4). Additional information on radionuclide concentrations in milk is obtained through the Atomic Energy Commission's Tri-City Diet Study (5) and through various State milk-sampling programs. With the resumption of atmospheric testing in late 1961, a general increase in average monthly radionuclide concentrations in milk was observed by the PMN (6).

Strontium-89. Noticeably increased strontium-89 activity in milk was exhibited in the spring of 1962 and 1963. However, concentrations of this radionuclide declined after the spring of 1963, becoming negligible by the spring of 1964 (3).

Strontium-90. The observed strontium-90 concentrations in milk from the PMN for the period 1960 through 1965 are presented graphically in figure 1. The average monthly concentration showed a general increase during 1962

¹ Prepared by Richard D. Grundy, senior technical editor, *Radiological Health Data and Reports*.

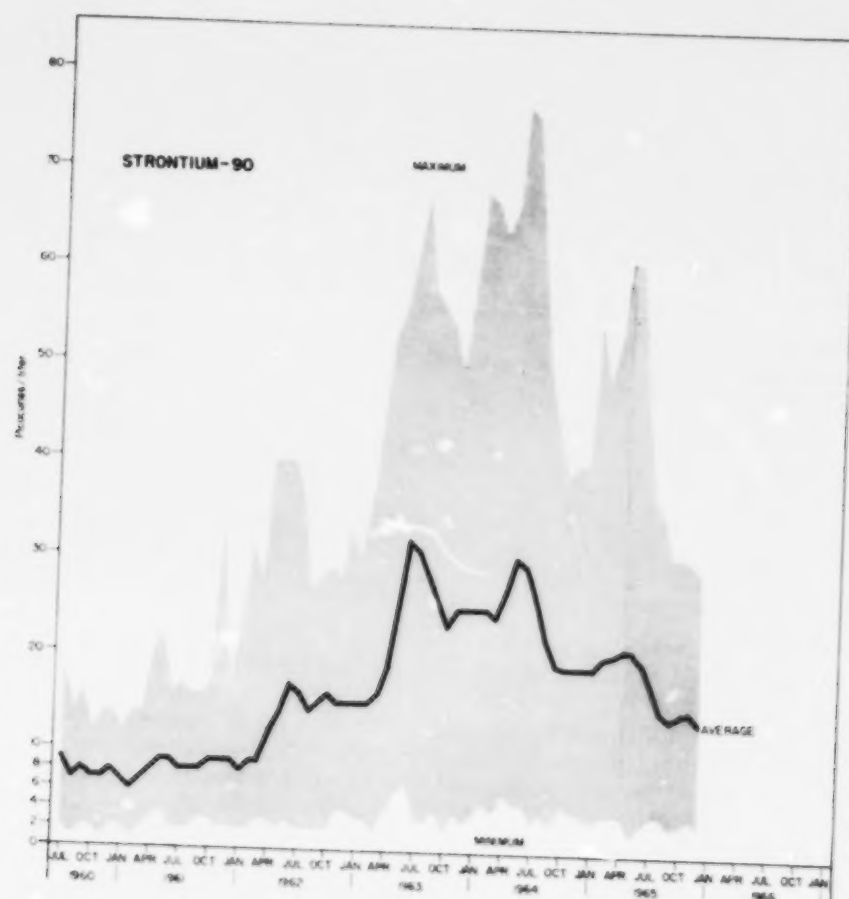


Figure 1. Average, maximum, and minimum concentrations of strontium-90 in milk from the Pasteurized Milk Network

and exhibited peaks in 1963 and 1964. Subsequently, the concentration of strontium-90 in milk declined.

For comparison with the FRC data (1,2), these concentrations, along with data obtained by the Tri-City Diet Study (3), are presented on a "wet" and "dry" are basis in table 1. It is observed that in the "wet" area, data produced by the two programs were in close agreement. In 1963, the PMN results were slightly below the FRC predictions.

In 1964, the results of both programs were slightly below the predicted concentration. Although not striking, this difference suggested that 1965 predictions might be (and were)

Table 1. Annual average strontium-90 content of U.S. milk 1961-1965, compared with Federal Radiation Council estimates for 1965 and estimates for 1966

Year	Strontium-90 content (pCi/g Ca)					
	"Wet" area*			"Dry" area*		
	New York (Tri-City)	PMN	Estimate	San Francisco (Tri-City)	PMN	Estimate
1961.....	10	10	—	5	5	—
1962.....	15	15	—	5	10	—
1963.....	30	25	^a 30	10	15	^a 10
1964.....	25	25	^b 30	10	15	^b 10
1965.....	15	20	^c 25	10	10	^c 5
1966.....	—	—	^c 20	—	—	^c 10

* Stated in Federal Radiation Council Report No. 4.

^b Stated in Federal Radiation Council Report No. 6.

^c Estimated herein using the approach employed in Federal Radiation Council Reports Nos. 4 and 6, and rounded to the nearest 5 pCi/g Ca.

somewhat high (3). Table 1 indicates that environmental contamination in 1967 was not as great as predicted for the "wet" area.

Considering the "dry" area, the Tri-City Diet Study milk results for 1963 and 1964 were in agreement with the FRC predicted concentrations. However, PMN results for 1964 and 1965 were slightly higher than the predicted concentrations. Compared to the 1965 predictions, results from both programs were somewhat high.

Predictions of 1966 levels have not been made by the FRC. However, predictions of strontium-90 content of milk can be made on the basis of strontium-90 depositions and the strontium-90 content of soil (7,8). Such estimates have been made by previous investigators (9-11) and employed by the FRC (1,2) on the basis of the following equation:

$$M = aS + bR \quad (1)$$

where M = strontium-90-to-calcium ratio in milk (pCi/g),

S = cumulative deposition of strontium-90 in the soil (mCi/mi²),

and R = average monthly strontium-90 fallout rate (mCi/m² month).

The proportionality constants, "a" and "b" developed on the basis of New York City's results (10) are:

$$a = 0.1 \times 10^{-9} \text{ mi}^2/\text{g Ca (8)}$$

$$b = 4.7 \times 10^{-9} \text{ mi}^2/\text{g Ca (8)}.$$

Thus, to predict the average annual strontium-90-to-calcium ratio in "wet area" milk, the following equation is used:

$$M = 0.1 S + 4.7 R \quad (2)$$

The accumulated deposition of strontium-90 in the United States through 1963 in the "wet" area was 150 mCi/mi² (2), while 1964 and 1965 depositions were 41 and 15 mCi/mi², respectively (9). Thus, the accumulated deposition through 1965 was 206 mCi/mi².

On the basis of the observed decrease in fallout deposition, it was estimated that 1966 strontium-90 deposition (R) would approximate 4 mCi/mi² (0.33 mCi/m² · month). Using these "wet-area" figures, the 1966 strontium-90 concentration in milk can be estimated from equation (2) as 22 pCi/g calcium.

The same approach can be applied to the

estimation of 1966 levels for the "dry area." Accumulated deposition of strontium-90 through 1963 was 65 mCi/mi². The 1964 and 1965 depositions in San Francisco, representative of the "dry area", were 7.5 and 5.4 mCi/m², respectively, for an accumulated deposition of 78 mCi/mi² through 1965 (10). On the basis of the observed strontium-90 depositions, it is estimated that 1966 deposition will approximate 3 mCi/m² (0.25 mCi/mi² · month). Using these "dry-area" figures, the 1966 strontium-90 concentrations in milk can be estimated as 10 pCi/g calcium. This is higher than the FRC 1965 estimate of 5 pCi/g calcium, which was lower than the 10 pCi/g calcium actually experienced.

Iodine-131. During 1965, iodine-131 concentrations in milk from the PMN averaged less than 10 pCi/liter. Occurrence of iodine-131 in milk since 1961 has been limited to periods immediately following the first (12) and second (13) Chinese atmospheric nuclear tests (figure 2). As predicted, iodine-131 in milk became undetectable by mid-1963 (2). Since the beginning of the program in 1961, the peak annual average was 104 pCi/liter. This peak occurred in 1962 at Palmer, Alaska. Using the assumption of 1 liter daily intake of milk, this annual average would correspond to Range III (100 to 1,000 pCi/day) as defined by the FRC (14).

Cesium-137. Cesium-137 concentrations in milk paralleled the strontium-90 results. A continued increase was observed from 1961 through 1964, when the peak concentrations of cesium-137 in milk occurred (figure 3). Subsequently, levels decreased through 1965. The annual averages in 1965 were 61 pCi/liter in the "wet" area, and 46 pCi/liter in the "dry" area.

Diet

Estimates of children's and teenagers' radionuclide intakes have been obtained since 1961, from the Institutional Total Diet Sampling Network (15) of the National Center for Radiological Health and the National Center for Urban and Industrial Health. This network, the Atomic Energy Commission's Tri-City Diet Study (5), and the Food and Drug Administration's Teenage Diet Survey (16) provide nationwide estimates of dietary intake of radio-

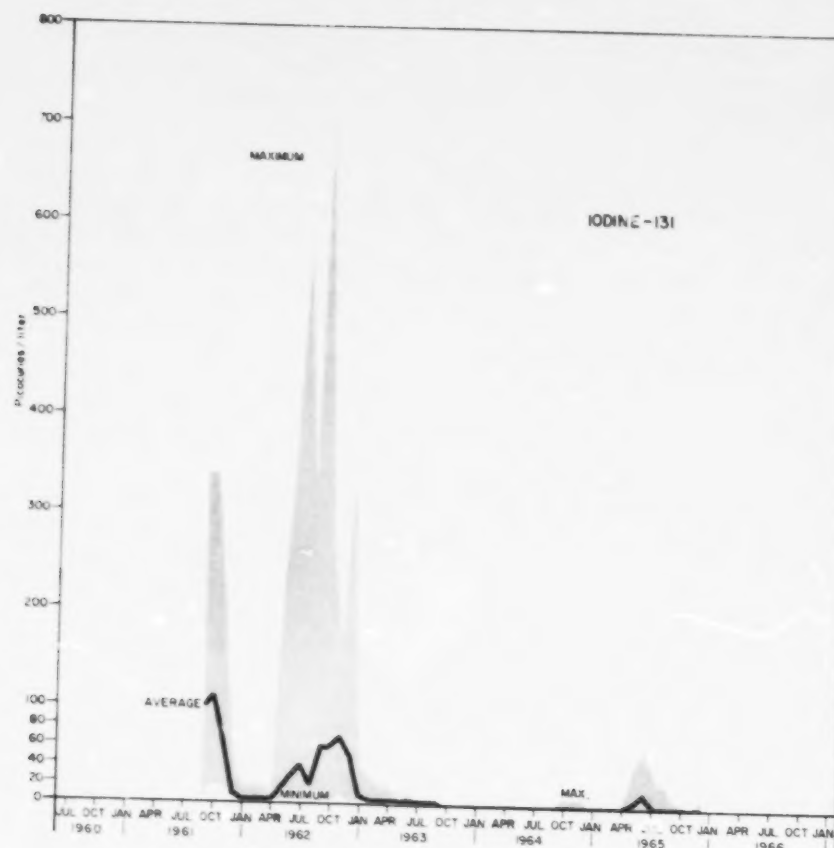


Figure 2. Average, maximum, and minimum concentrations of iodine-131 in milk from the Pasteurized Milk Network

nuclides. The characterization of radionuclide concentrations in the diet constitutes an important element of any population-oriented radiological surveillance program.

Strontium-89. Increased levels of strontium-89 in the diet were observed in the Institutional Diet samples in late 1961, following the resumption of atmospheric nuclear testing (17). The average daily intake reached peaks in mid-1962 and 1963, and declined thereafter (3). Concentrations of this radionuclide in the diet diminished to negligible levels by early 1964. The annual average daily intake was approximately the same in mid-1962 and mid-1963. These observations were in agreement with FRC predictions (1). The maximum annual average strontium-89 intake at any institution during this period was 182 pCi/day in 1963 (4). Except for a few isolated instances immediately following the first and second

Chinese atmospheric nuclear tests, strontium-89 concentrations during 1965 remained below detectable levels.

Strontium-90. Unlike strontium-89, strontium-90 has been observed in the Institutional Diet samples continuously since the inception of the network in 1961. After the resumption of nuclear testing in 1961, the average daily intake increased steadily, reaching a maximum in the spring of 1964 (figure 4). The network annual average intakes were 13 pCi/day in 1962; 25 pCi/g Ca in 1963; and 32 pCi/day in 1964, corresponding to approximately 12, 22, and 28 pCi/day, respectively.²

During 1965 the network annual average was 28 pCi/day, corresponding to 25 pCi/g calcium. The observed decreasing trend is ex-

² Based upon an intake of 1.13 grams of calcium per day (17).

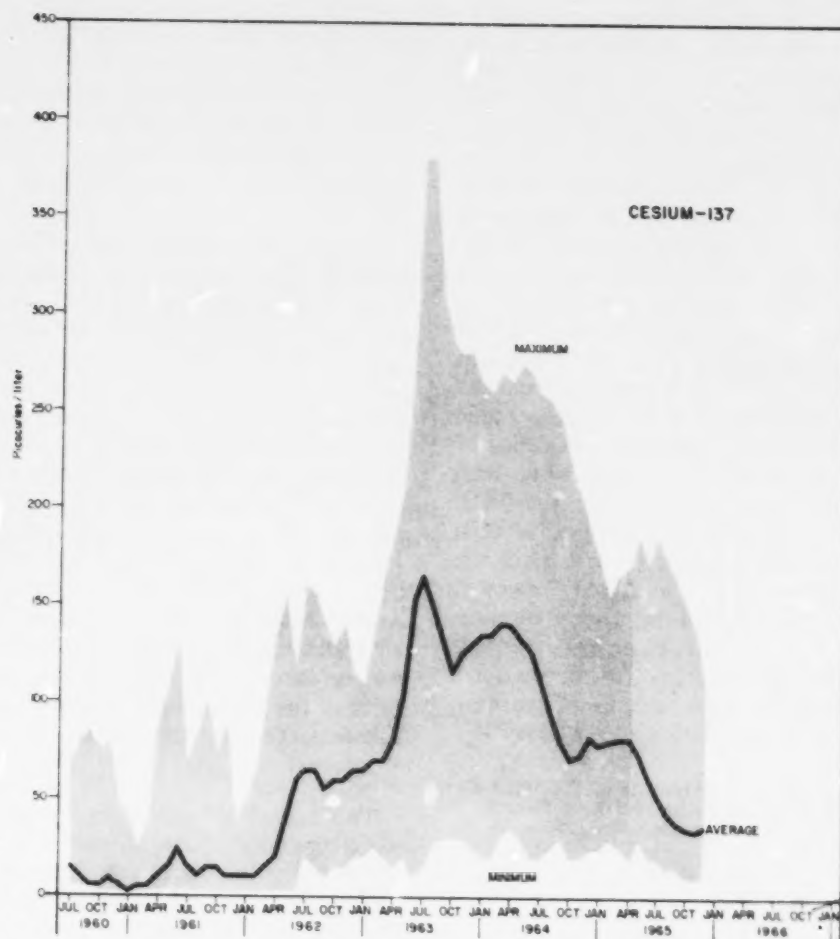


Figure 3. Average, maximum, and minimum milk concentrations of cesium-137 in the Pastuerized Milk Network

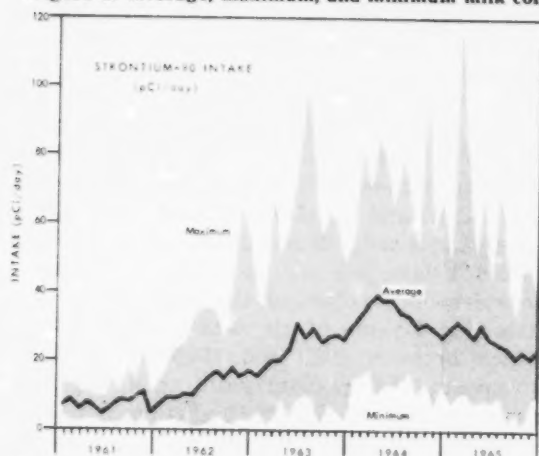


Figure 4. Monthly average strontium-90 intakes and ranges in Institutional Total Diet Sampling Network

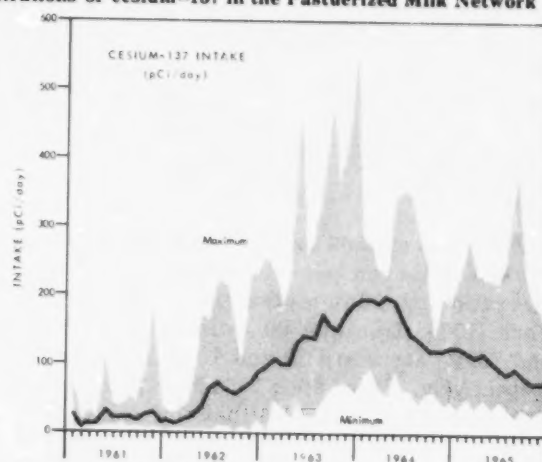


Figure 5. Monthly average cesium-137 intakes and ranges in Institutional Total Diet Sampling Network

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pected to continue through 1966. The highest annual average intake for an individual institutional sampling station from 1961 to 1965 was 48 pCi/day, observed during 1964. This corresponds to Range II (20 to 200 pCi/day) as defined by the FRC (14).

Similar patterns of strontium-90 dietary intake were reflected in the Tri-City Diet Study (5) and the Teenage Diet Survey (16). Strontium-90 dietary intakes increased during 1961 and 1962, reaching a maximum in the spring of 1964. Comparisons of these dietary results with the FRC estimates (1,2) are shown in table 2. For the "wet" area, the results from the two sampling programs were in reasonable agreement for all years, although the ratios of strontium-90 to calcium observed were uniformly below the values predicted by the FRC. In the "dry" area the observed results for both programs were also somewhat lower than the predicted ratio for 1963 and 1964. However, in 1965 the Institutional Total Diet Sampling Network result, representing several sampling locations, was higher than the FRC predictions. The Tri-City result, representing San Francisco, was lower than the prediction.

Table 2. Average strontium-90 content of U.S. total diet 1961-1965, compared with Federal Radiation Council estimates, 1965, and estimates for 1966

Year	Strontium-90 content (pCi/g Ca)					
	"Wet" area *			"Dry" area *		
	New York (Tri-City)	Institutional diet	Estimate	San Francisco (Tri-City)	Institutional diet	Estimate
1961.....	5	10	—	5	5	—
1962.....	10	10	—	5	5	—
1963.....	30	25	* 50	10	10	* 35
1964.....	30	30	* 40	10	20	* 20
1965.....	20	20	* 30	10	20	* 15
1966.....	—	—	* 30	—	—	* 15

* Stated in Federal Radiation Council Report No. 4.

† Stated in Federal Radiation Council Report No. 6.

* Estimated herein using the approach employed in Federal Radiation Council Reports Nos. 4 and 6 and rounded to nearest 5 pCi/g Ca.

Estimates of 1966 total diet strontium-90-to-calcium ratios can be made, assuming that total diet ratios are 1.5 times that predicted for milk. Thus, 1966 strontium-90 estimates for "wet" and "dry" areas are 30 and 15 pCi/g calcium, respectively. Based upon 1964 and 1965 results, it is reasonable to expect that this estimate is high.

Iodine-131. Annual average iodine-131 intakes during 1965 were essentially zero. Except for isolated samples immediately following the first and second Chinese atmospheric nuclear tests, iodine-131 intakes have not been significantly different from zero pCi/day since mid-1963, which is consistent with the predictions (2).

Cesium-137. During 1965, the cesium-137 dietary intake, as observed in the Institutional Total Diet Sampling Network, averaged 105 pCi/day. Dietary intakes of cesium-137 decreased throughout 1965 (figure 5) paralleling the strontium-90 intake. Since 1961, the peak annual average intake on a daily basis was 154 pCi/day, observed in 1964. This is well below the value of 4,400 pCi/day for the population at large, which can be derived from International Commission on Radiological Protection (ICRP) recommendations (18). Federal Radiation Council estimates of dietary intake of cesium-137 have not been made. However, as with strontium-90, cesium-127 dietary intakes can be expected to decrease during 1966. Results of the FDA Teenage Diet Survey further substantiate this expected decrease (16).

Bone

The extent to which strontium-90 has entered the food chain of man has been shown in the foregoing discussion. The resultant levels of strontium-90 in man can be described by the ratio of strontium-90 to calcium in bone.

For consistency with the presentation in FRC Reports Nos. 4 and 6, the 0- to 4-year-old age group is considered. Table 3 shows the observed strontium-90-to-calcium ratios in bone from 1958 to 1965 for the AEC's Health and Safety Laboratory (HASL) (19) and Public Health Service (20) programs, along with FRC estimates for 1963 through 1965. Close agreement was not obtained between the predictions and the observed data, but a difference of this order is not unexpected. The predicted values are for new bone, whereas a considerable fraction of the bones of individuals 0 to 4 years of age was preformed bone which between 1963 and 1965 had a lower strontium-90-to-calcium ratio than the bone more recently formed. Predictions of 1966 levels for new bone are 8 and 4 pCi/g Ca in the

"wet" and "dry" areas, respectively, based upon the FRC assumption that one-fourth of the dietary concentration of strontium-90 is deposited in new bone and that the strontium-90-to-calcium ratio in old bone is the same as in new bone.

Table 3. Average strontium-90 content of human bone in the United States, for 0- to 4-year olds at death 1958-1965

Year	Strontium-90 content (pCi/g Ca)					
	"Wet" area			"Dry" area		
	Esti- mated ^a	Observed		Esti- mated ^a	Observed	
		HASL	PHS		HASL	PHS
1958		2.0			2.0	
1959		2.7			2.2	
1960		2.4			1.8	
1961		2.6			0.9	
1962		3.1	3.2		1.1	
1963	12	5.0	4.8	9	1.9	
1964	10	6.0	3.4	5	2.7	2.7
1965	8	6.2	4.4	4	3.1	2.3
1966	^b 8			^b 4		

^a 1963, 1964, and 1965 values are predicted by assuming one-fourth of the dietary level of strontium-90 is deposited in new bone in 0- to 4-year-old children (12), and assuming that the strontium-90-to-calcium ratio of old bone in this group is the same as that of new bone.

^b Estimated herein using the approach employed in FRC Report Nos. 4 and 6.

Estimated dose

It is possible to estimate annual dose rates to children from the observed strontium-90 in bone and cesium-137 concentrations in milk. The resultant radiation dose rate from the indicated strontium-90 concentrations in bone may be estimated from the dose conversion factor presented by the FRC (21). Thus the highest average bone level shown, 6.2 pCi/g calcium in 1965, would result in a dose rate to bone marrow of approximately 5.5 millirad in 1 year.

For cesium-137, the yearly dose (assuming equilibrium) can be calculated from the following:

$$D = (11) \frac{I}{W} 1.44T_e \quad (3)$$

where

D = dose (rads),

11 = conversion constant (kg-rads/ μ Ci-day),

I = daily intake of cesium-137 (μ Ci/day),

W = body weight (kg),

and T_e = effective half-life (days).

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For infants, the effective half-life is taken to be 30 days, and the body weight as 10 kg (21); also, it is assumed that 1 liter is the daily intake of milk. For the "wet" area, with a 1965 average for cesium-137 in milk of 105 pCi/liter, the resultant dose rate would be approximately 5.2 millirad for the year. Since both strontium-90 and cesium-137 contribute to bone-marrow dosage, the sum of the estimated doses is of significance (21); thus, the estimated total dose rate to bone marrow would be approximately 11 millirad during 1965 for young children in the "wet" area.

For long-term low-level situations, such as are represented by these data, specific guidance has not been recommended by the FRC. Rather, annual doses from fallout equal to, or greater than, the numerical values of the Radiation Protection Guides (RPG's) can be used as an indication of when there is a need for careful evaluation of fallout exposures. The RPG for total bone for the general population is given as 500 mrad/year (14). Thus, in the above case, the dose rate owing to strontium-90 and cesium-137 for young children in the "wet" area amounts to approximately 2 percent of the RPG.

Summary

The estimates made in FRC Reports Nos. 4 and 6 regarding the average concentrations of radionuclides in the environment and man for 1965 have been essentially verified by the 1965 surveillance data. The peak intake of radionuclides by the population groups selected occurred in 1964. The conclusion is that the predictions made in FRC Reports Nos. 4 and 6, and the projected radiation dose rate appear valid and reasonable for the situation as it exists currently.

Based upon predictions of dietary contamination levels in 1963 and subsequent years, the FRC concluded in Reports Nos. 4 and 6 that health risks from radioactivity in food over the next several years are too small to justify protective actions to limit the dietary intake of radionuclides, particularly milk and dairy products. The observed radionuclide levels are in agreement with these predictions and substantiate conclusions of the Federal Radiation Council.

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STRONTIUM-90 DIETARY INTAKE ESTIMATES BASED ON FRACTIONAL INTAKES DUE TO MILK

Richard D. Grundy¹

Strontium-90 dietary intake estimates were made for the Institutional Total Diet Sampling Network based upon Pasteurized Milk Network concentrations. Approaches based upon milk-to-total-diet ratios of strontium-90 and strontium units were considered. The approach based upon strontium units yielded the best estimates of ITDSN monthly average and maximum strontium-90 intakes on a network basis for the population groups involved.

The Federal Radiation Council (FRC) stresses the determination of internal exposures to man from environmental radiation sources, particularly from radionuclides in the diet. While the more accurate measure of intake is through total diet measurements, indicator foods have been proposed to estimate dietary intakes of such radionuclides as strontium-90.

Fresh whole milk representing the major source of calcium in the diet, has been suggested as such an indicator food. As a result of its high consumption rate in the United States, milk and milk products represent the largest single source of strontium-90 intake. However, milk contains a lower level of strontium-90 per unit calcium² than the average for the non-milk portion of the diet. This lower level is due to discrimination in favor of calcium over strontium in the cow's metabolic processes.

Further discrimination in man's metabolic processes results in a decrease in the strontium-90-to-calcium ratio to the extent that this ratio in bone is about one-fourth of the strontium-calcium ratio in the total diet (1). As a result of the two-stage process (cow-milk-man), strontium unit levels are lower for those segments of the population with the same average diet, but with lower milk consumption (2).

¹ Mr. Grundy is chief, Data Analysis and Operations Section, Standards and Intelligence Branch, National Center for Radiological Health, Rockville, Maryland 20852.

² A common term for expressing strontium-90-to-calcium ratios in milk, total diet, and bone is "strontium units." It is expressed in picocuries of strontium-90 per gram of calcium.

Although the fallout levels in the Southern Hemisphere are an order of magnitude lower than in the Northern Hemisphere, the bone levels of strontium-90 in the United States are about double those found in the primarily plant-consuming cultures located in equatorial and Southern Hemisphere portions of the world (2).

This paper presents, on a national basis, an analysis of the fractional intakes of strontium-90 resulting from milk for the population group represented by the ITDSN. An attempt was made to evaluate the use of milk strontium-90 concentrations and strontium-90-to-calcium ratios to estimate dietary intakes for the conterminous United States.

Evaluation on an individual station basis was not feasible at this time because of the limited number of samples available. For the purpose of this presentation, levels in milk were related to those in the total diet (including milk). In this manner, a fractional intake (or percent of intake) due to milk was obtained. The data used were from the Public Health Service's Institutional Total Diet Sampling Network and Pasteurized Milk Network (PMN) for the period 1963 through 1964. Ratios were calculated using both strontium-90 concentrations in milk and total diet and strontium unit values. The results are presented below. It should be noted that the ratios developed are the reciprocal of ratios cited by previous investigators based upon observed and/or assumed milk intakes (2-5).

Strontium-90 dietary intakes

At the present time, ITDSN stations are collecting monthly total diet samples which are analyzed for calcium, strontium-90, and other selected radionuclides. The results define the dietary intake of strontium-90 for the population group represented by the Institutional Total Diet Sampling Network. The observed results indicate that, during the first 8 months of 1961, the average strontium-90 intake was 8 pCi/day. With the resumption of atmospheric nuclear testing in the fall of 1961, a steady increase was observed until April 1964 at an annual rate of approximately 10 pCi/day (6). At that time a decreasing trend ensued upon which was superimposed the expected seasonal variation involving a spring rise. Currently, dietary intakes of strontium-90 are within Range II (20-200 pCi/day) as defined by the FRC (1). Maximum dietary intakes have remained below 100/pCi day at all times. At these levels, the FRC requires quantitative surveillance and routine control (1).

Fractional intakes of strontium-90

In order to determine milk fractional intakes of strontium-90, it is necessary to know the actual weights of milk and non-milk portions of the diet. Although routine ITDSN reporting procedures report total dietary consumption values, milk consumption weights are obtained at the time of sample collection and are available.

Since it was proposed to use PMN milk results in conjunction with ITDSN total diet results, it was necessary to determine the validity of interrelating results from these networks. Evaluation was made for the period July 1963 through May 1964. During this period the ITDSN separately collected and analyzed the milk and non-milk portions of the diet. For routine reporting purposes, results were then combined to obtain ITDSN total strontium-90 intakes. In a similar manner PMN milk results were used in place of ITDSN milk results, and the resultant strontium-90 intakes calculated as a basis for further calculations as presented herein.

Evaluation of the two methods of calculating strontium-90 fractional intakes was performed

by first calculating, on the basis of individual ITDSN station results, the monthly fractional intakes of strontium-90 resulting from ITDSN milk [MTD (^{90}Sr)_I] as follows:

$$\text{MTD } (^{90}\text{Sr})_I = \frac{\text{Con}_m \cdot \text{Sr}_m (\text{ITDSN})}{\text{Con}_d \cdot \text{Sr}_d} \quad (1)$$

where

Con_m = milk consumption (kg/day), monthly ITDSN value,

Sr_m (ITDSN) = strontium-90 concentrations in milk (pCi/kg), monthly ITDSN value,

Con_d = total diet consumption (kg/day), monthly ITDSN value,

and

Sr_d = strontium-90 concentration in total diet, (pCi/kg), monthly ITDSN value.

On the basis of 123 monthly station results, a mean milk fractional intake of strontium-90 of 0.54 was observed, with a standard deviation of 0.17. It should be emphasized that to obtain this ratio, it was necessary to perform monthly analyses on both the milk and non-milk fractions of the total diet. On a routine basis, this serves no practical advantage, since a single analysis on the total diet sample would have provided the desired strontium-90 intake figures.

Milk monthly fractional intakes of strontium-90 were then calculated using PMN sample results. If possible, PMN stations and ITDSN stations were selected within the same municipality. Where this was not feasible the nearest sampling station within the same State was selected. The resultant milk fractional intakes [MTD (^{90}Sr)_P] were calculated using equation (2):

$$\text{MTD } (^{90}\text{Sr})_P = \frac{\text{Con}_m \cdot \text{Sr}_m (\text{PMN})}{\text{Con}_d \cdot \text{Sr}_d} \quad (2)$$

where

Sr_m (PMN) = strontium-90 concentration in milk (pCi/kg), monthly average PMN value.

On the basis of 418 monthly ratios for 1963 and 1964, a mean milk fractional intake of 0.58 was observed, with a standard deviation of 0.22. The MTD ratios using both ITDSN and PMN strontium-90 concentrations in milk and

ITDSN total diet strontium-90 concentrations are summarized in table 1.

Assuming "normal" distribution of the ratios, the results of the two methods of calculation were statistically compared on the basis of a test as follows:

$$Z = \frac{\text{MTD } (^{90}\text{Sr})_P - \text{MTD } (^{90}\text{Sr})_I}{\sqrt{\frac{\sigma_I^2}{n_I} + \frac{\sigma_P^2}{n_P}}} \quad (3)$$

$$Z = 2.17 > Z(0.05) = 1.64$$

It was apparent from the test that the observed means of the two methods were statistically different at the 5-percent level of significance. Therefore, before attempting to use the approach based upon strontium-90, the strontium unit (strontium-90-to-calcium ratio) approach was investigated.

Table 1. Fractional dietary intakes of strontium-90 resulting from milk

	MTD (^{90}Sr) _I	MTD (^{90}Sr) _P
Number of samples (n).....	123	418
Mean.....	0.54	0.58
Standard deviation (σ).....	0.17	0.22
90-percent confidence interval ($\pm 1.64\sigma$).....	0.26 to 0.82	0.22 to 0.94

Strontium-90-to-calcium ratio approach

Strontium-90 is similar to calcium biochemically, and the metabolism of strontium is linked to the metabolism of calcium in a complex way (1). Although the body preferentially absorbs calcium and preferentially excretes strontium, both are incorporated into new bone in the same ratio as they exist in blood (1). This metabolic similarity makes it useful to consider ratios of these two elements when evaluating dietary intakes of strontium-90.

Using the monthly ITDSN results, milk-to-total-diet ratios of strontium units [MTD (SU)_I] were calculated on an individual station basis for the period of July 1963 through May 1964, as follows:

$$\text{MTD (SU)}_I = \frac{\text{Sr}_m (\text{ITDSN}) \cdot \text{Ca}_d}{\text{Ca}_m (\text{ITDSN}) \cdot \text{Sr}_d} \quad (4)$$

where

Ca_m (ITDSN) = calcium concentrations in milk (g/kg), monthly ITDSN value,

and Ca_d = calcium concentration in total diet (g/kg), monthly ITDSN value.

On the basis of 143 monthly values, a mean strontium unit fractional ratio of 0.88 was observed, with a standard deviation of 0.29.

Strontium unit ratios were then calculated using individual PMN station monthly average milk concentrations.

PMN stations and ITDSN stations were selected so as to be comparable. The resultant fractional ratios [MTD (SU)_P] were calculated using equation (5).

$$\text{MTD (SU)}_P = \frac{\text{Sr}_m (\text{PMN}) \cdot \text{Ca}_d}{\text{Ca}_m (\text{PMN}) \cdot \text{Sr}_d} \quad (5)$$

where

Ca_m (PMN) = average calcium concentration in milk (g/kg), monthly average PMN station value.

On the basis of 641 monthly values a mean fractional ratio of 0.90 was observed with a standard deviation of 0.26.

The MTD (SU) ratios, using both ITDSN and PMN milk concentrations and ITDSN total diets results, are summarized in table 2. Comparison of results of the two methods of calculation on the basis of a "Z" test indicates that the two distributions are statistically the same at the 5 percent level of significance, where:

$$Z = \frac{\text{MTD (SU)}_P - \text{MTD (SU)}_I}{\sqrt{\frac{\sigma_I^2}{n_I} + \frac{\sigma_P^2}{n_P}}} \quad (6)$$

$$Z = 0.76 < Z(0.05) = 1.64$$

This suggests that the approach based upon the strontium unit is the optimum approach upon which to base estimates.

Table 2. Ratio of milk and total diet strontium-90-to-calcium values

	MTD (SU) _I	MTD (SU) _P
Number of samples (n).....	143	641
Mean.....	0.88	0.90
Standard deviation (σ).....	0.29	0.26
90-percent confidence interval ($\pm 1.64\sigma$).....	0.42 to 1.36	0.47 to 1.32

Estimates and evaluations

The strontium unit ratio approach based

upon PMN milk results indicates a mean ratio $[\text{MTD}(\text{SU})_P]$ of 0.90 for the period of January 1963 through December 1964. Using this 2-year mean ratio, estimates of ITDSN strontium-90 intakes for the conterminous United States were made as follows:

$$Sr_d = \frac{\overline{Ca_d}}{\overline{\text{MTD}(\text{SU})_P}} \cdot \overline{\text{SU}}(\text{PMN}) \quad (7)$$

where

Sr_d = estimated average ITDSN strontium-90 intake (pCi/day),

$\overline{Ca_d}$ = monthly average ITDSN calcium intake (g/day),

$\overline{\text{SU}}(\text{PMN})$ = PMN monthly average strontium-90-to-calcium ratio (pCi/g),

and

$\text{MTD}(\text{SU})_P$ = average milk to total diet strontium-90-to-calcium ratio

$$= \frac{[\text{pCi/g}]_{\text{PMN}}}{[\text{pCi/g}]_{\text{ITDSN}}} = 0.90.$$

Estimates were made of monthly average ITDSN strontium-90 intakes, Sr_d , based on PMN strontium-90 concentrations in milk for the period January through June 1965. Estimates based upon a 1963 through 1964 mean milk to total diet strontium unit ratio of 0.90 were observed to be uniformly less than the observed monthly average ITDSN strontium-90 intakes by 20 to 25 percent. When comparison was made between 1963 and 1964 ratio values, the 1964 strontium unit ratio was observed to be below the 2-year value. This suggests that, relative to the total diet, the importance of milk as a dietary source of strontium-90 had decreased between 1963 and 1964. This trend is in agreement with the results observed for cesium-137 (9), and required consideration in applying MTD ratios.

Using the 1964 mean ratio of 0.77 $[\text{MTD}(\text{SU})_P]$, estimates of ITDSN monthly average strontium-90 intake were made for January through June 1965 (table 3), using PMN milk concentrations. The estimated strontium-90

Table 3. Estimated and observed ITDSN monthly average strontium-90 intakes, January-June 1965

Month	Observed strontium-90 milk concentrations ^a (pCi/g)	Observed calcium intake ^b (g/day)	Estimated strontium-90 intake ^c		Observed average strontium-90 intake (pCi/day)
			0.90 ^d (pCi/day)	0.77 ^e (pCi/day)	
January.....	16.1	1.2	22	28	28
February.....	16.8	1.3	24	32	32
March.....	16.8	1.3	24	30	30
April.....	17.8	1.3	26	30	28
May.....	17.6	1.3	26	28	31
June.....	17.1	1.2	23	27	27

^a Monthly average PMN strontium unit ratio (SU_m)

^b Monthly average ITDSN dietary intake of calcium (Ca_d)

^c Mean Sr_d for month

^d Mean $\text{MTD}(\text{SU})_P$ for 1963 through 1964 based upon PMN milk concentrations and ITDSN total diet values

^e Mean $\text{MTD}(\text{SU})_P$ for 1964

intakes were uniformly within 10 percent of the ITDSN observed intakes. The ability of this approach to estimate monthly average strontium-90 intakes based upon the previous year's milk-to-total-diet ratio was thus demonstrated.

An evaluation was also made of the ability of the approach to estimate monthly maximum intakes for the population group represented by the ITDSN. The 1964 mean milk to total diet strontium unit ratio of 0.77 was used to estimate maximum strontium-90 intakes (table 4). Maximum monthly PMN strontium-90 to calcium values and monthly average ITDSN calcium intakes were used. It was observed that, except for April 1965, estimated maximum intakes of strontium-90 were within 17 percent of observed maximum intakes. In the case of April 1965, the estimated maximum strontium-90 intake was 40-percent high. It is appropriate to note at this point that the approach presented herein was developed on a

Table 4. Estimated and observed ITDSN maximum monthly strontium-90 intakes, January-June 1965

Month	Observed maximum strontium-90 milk concentrations ^a (pCi/g)	Observed calcium intake ^b (g/day)	Estimated maximum strontium-90 intake ^c (pCi/day)	Observed maximum strontium-90 intake (pCi/day)
January.....	41.2	1.2	64	64
February.....	36.9	1.3	63	73
March.....	39.3	1.3	67	81
April.....	45.2	1.3	77	55
May.....	42.3	1.3	71	69
June.....	34.8	1.2	48	45

^a Monthly maximum PMN strontium unit ratio (SU_{max} (PMN))

^b Monthly average ITDSN dietary intake of calcium (Ca_d)

^c Based upon maximum monthly PMN milk concentrations $\text{MTD}(\text{SU})_P = 0.77$ for 1964

network basis. Application on an individual station basis was not intended.

Discussion

Using ITDSN milk and total diet intakes in conjunction with PMN monthly average milk concentrations, fractional intakes of strontium-90 due to milk were calculated for the period 1963 through 1964 for the conterminous United States. Comparison between distributions of strontium-90 milk-to-total-diet ratios [MTD (^{90}Sr)] based upon (1) ITDSN milk and (2) PMN milk concentrations showed that the two methods of calculation yielded statistically different distributions at the 5-percent level of significance.

However, when milk-to-total-diet strontium unit ratios were calculated using both methods (ITDSN and PMN milk results), the resultant distribution could be considered statistically equivalent at the 5-percent level of significance. The feasibility of using PMN milk results in conjunction with ITDSN total diet results on a network basis was thus demonstrated.

For the purpose of making average and maximum ITDSN strontium-90 intake estimates, the strontium-unit approach based upon PMN milk concentrations was selected. Due to an observed decrease in the relative importance of milk as a dietary source of strontium-90 between 1963 and 1964, the 1964 mean ratio [MTD(SU)_r] of 0.77 was used to estimate 1965 strontium-90 intakes for the population group represented by the ITDSN. The 1964 mean ratio corresponds to a total-diet-to-milk ratio [TDM(SU)] of 1.30 for the conterminous United States. This mean value, while slightly lower, is comparable to 1.2 as obtained by Kulp and Schulert (3,4) and by Michelson (5), and further suggests a decrease in the relative importance of milk as a dietary source of strontium-90 since the period covered by these studies (3-5).

At current strontium-90 intake levels, the method presented herein is applicable where actual intakes are unknown. Although the relative importance of milk as a dietary source of strontium-90 decreased between 1963 and 1964, the 1964 mean strontium unit ratio facilitated estimates of 1965 observed monthly intakes on an ITDSN basis. Application of

results presented herein to other than the ITDSN on a national basis must take into consideration regional variations and the population group of concern. Current efforts are directed toward an expansion of the material presented herein in an effort to quantitatively define regional variations and time variations in the strontium unit ratio.

Acknowledgments

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Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. The total diet is the most direct measure of intake of radionuclides; however, since specific dietary data are not readily available, indicator foods may be used to estimate radionuclide intake. As fresh milk is consumed by a large segment of the U.S. population, contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet and is the major source of dietary intake of short-lived radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analyses of the total diet or representative principal food items or groups combined with appropriate consumption data.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (1-3). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they provide an indication of when there is a

need to initiate careful evaluation of exposure (3). Additional guidelines are provided by the FRC Protective Action Guides (4) and by the International Commission on Radiological Protection (5,6).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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NATIONAL AND INTERNATIONAL MILK SURVEILLANCE

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide levels in

milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrotrium in milk, HASL	July-December 1965	June 1966

1. Pasteurized Milk Network October 1966

National Center for Radiological Health and
National Center for Urban and
Industrial Health, PHS

The Public Health Service's Pasteurized Milk Network (PMN), was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas.

The present network of 63 sampling stations (figure 1) provides data on milk in every State, the Canal Zone, and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1966 issue of *Radiological Health Data and Reports* (1).

The results for the third quarter of 1966 and October 1966 are presented in table 1. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values were

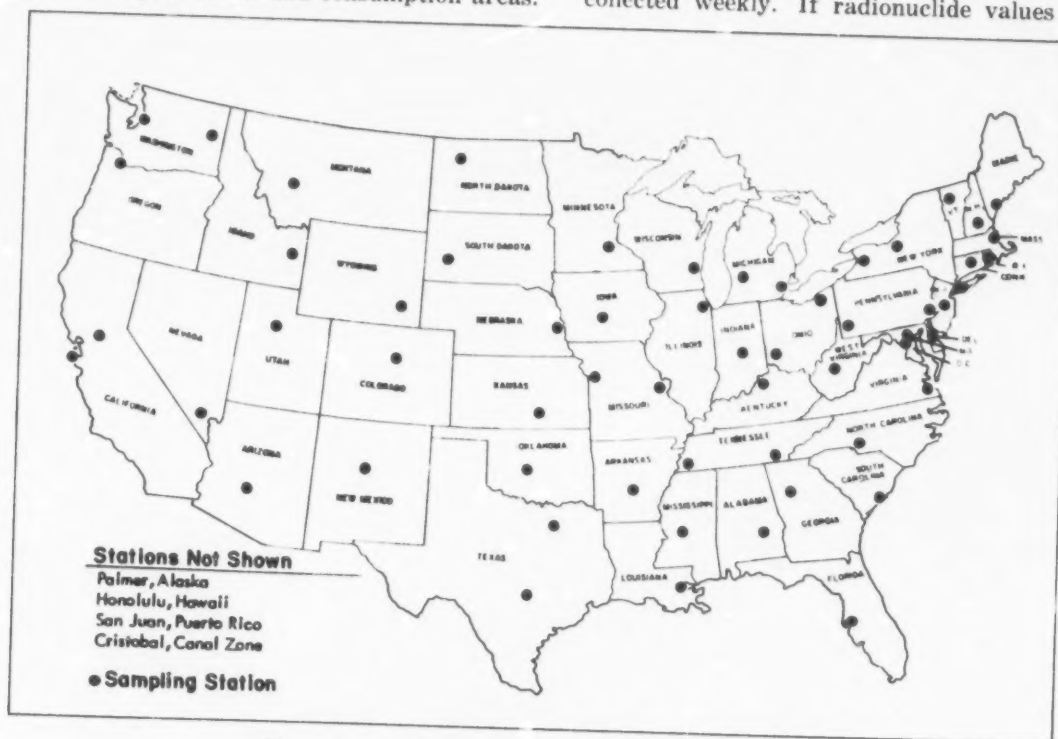


Figure 1. Pasteurized Milk Network sampling stations

Table 1. Average concentrations of radionuclides in pasteurized milk for the third quarter 1966 and October 1966 *

Station location		Concentration (pCi/liter)							
		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		Third quarter	Oct 1966	Third quarter	Oct 1966	Third quarter	Oct 1966	Third quarter	Oct 1966
Ala:	Montgomery	<5	NA	12	10	0	0	20	15
Alaska:	Palmer	<5	<5	11	14	0	0	30	15
Ariz:	Phoenix	<5	<5	3	3	0	0	10	<5
Ark:	Little Rock	<5	NA	24	23	0	0	25	20
Calif:	Sacramento	<5	<5	4	3	10	0	10	5
	San Francisco	<5	<5	4	3	0	0	15	5
C. Z.:	Cristobal	<5	NA	4	5	0	0	15	25
Colo:	Denver	<5	<5	7	9	0	0	15	5
Conn:	Hartford	<5	<5	11	11	0	0	30	20
Del:	Wilmington	<5	NA	12	12	0	0	20	20
D. C.:	Washington	<5	NA	11	11	0	0	15	15
Fla:	Tampa	<5	NA	10	10	0	0	135	120
Ga:	Atlanta	5	NA	19	19	0	0	25	25
Hawaii:	Honolulu	<5	<5	4	3	0	0	20	15
Idaho:	Idaho Falls	<5	<5	10	11	0	0	20	15
Ill:	Chicago	<5	<5	8	8	0	0	20	15
Ind:	Indianapolis	<5	NA	10	9	0	0	15	15
Iowa:	Des Moines	<5	<5	12	8	0	0	20	15
Kans:	Wichita	<5	<5	11	13	0	0	10	10
Ky:	Louisville	<5	NA	16	13	0	0	10	10
La:	New Orleans	<5	<5	32	27	0	0	55	40
Maine:	Portland	<5	NA	14	15	0	0	50	45
Md:	Baltimore	<5	<5	15	13	0	0	20	15
Mass:	Boston	<5	<5	9	8	0	0	20	15
Mich:	Detroit	<5	NA	12	11	0	0	25	20
	Grand Rapids	<5	<5	17	21	0	0	25	20
Minn:	Minneapolis	<5	NA	20	19	0	0	25	20
Miss:	Jackson	<5	<5	13	13	0	0	10	10
Mo:	St. Louis	5	<5	15	15	0	0	20	15
Mont:	Helena	<5	<5	10	11	0	0	25	25
Neb:	Omaha	<5	<5	11	11	0	0	15	10
Nev:	Las Vegas	<5	<5	4	4	0	0	10	5
N. H.:	Manchester	<5	NA	18	14	0	0	75	45
N. J.:	Trenton	<5	NA	11	10	0	0	20	20
N. Mex:	Albuquerque	<5	<5	7	4	0	0	10	10
N. Y.:	Buffalo	<5	<5	10	9	0	0	25	20
	New York City	<5	NA	14	11	0	0	30	25
	Syracuse	<5	<5	10	9	0	0	25	20
N. C.:	Charlotte	<5	NA	20	19	0	0	25	20
N. Dak:	Minot	<5	<5	21	26	0	0	25	20
Ohio:	Cincinnati	<5	NA	11	12	0	0	15	10
	Cleveland	<5	NA	11	10	0	0	20	15
Okla:	Oklahoma City	<5	5	12	11	0	0	10	10
Ore:	Portland	<5	<5	11	11	0	0	30	15
Pa:	Philadelphia	<5	<5	11	11	0	0	20	20
P. R.:	Pittsburgh	<5	NA	7	5	0	0	25	20
R. I.:	San Juan	<5	NA	15	13	0	0	35	25
	Providence	<5	NA	15	13	0	0	35	25
S. C.:	Charleston	<5	<5	20	22	0	0	50	35
S. Dak:	Rapid City	<5	<5	14	20	0	0	15	15
Tenn:	Chattanooga	<5	NA	20	18	0	0	25	20
	Memphis	<5	NA	16	16	0	0	10	10
Tex:	Austin	<5	NA	5	3	0	0	10	5
	Dallas	<5	<5	11	11	0	0	10	10
Utah:	Salt Lake City	<5	<5	9	10	0	0	15	15
Vt:	Burlington	<5	NA	12	12	0	0	35	25
Va:	Norfolk	<5	NA	16	15	0	0	20	15
Wash:	Seattle	<5	<5	18	17	0	0	55	45
W. Va:	Snokane	<5	<5	12	16	0	0	30	25
Wis:	Charleston	<5	NA	8	9	0	0	15	10
Wyo:	Milwaukee	<5	NA	9	8	0	0	20	15
	Laramie	<5	<5	9	8	0	0	15	10
Network average		<5	<5	12.3	12.0	0	0	25	20

* Barium-140 concentrations were below detectable levels.
NA, no analysis.

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below minimum detectable concentrations (1), averages were calculated using one-half the minimum detectable value; however, for iodine-131 and barium-140, zero was used for averaging purposes when concentrations were below minimum detectable levels.

Table 2. Frequency distribution, Strontium-90 concentrations in milk at Pasteurized Milk Network stations October 1965 and May-October 1966

Strontium-90 (pCi/liter)	Number of stations						
	1965		1966				
	Oct.	May	June	July	Aug.	Sept.	Oct.
Under-10	8	10	9	14	15	21	18
10-19	46	38	41	39	40	37	39
20-29	7	12	10	9	7	5	6
30-39	2	3	3	1	1	0	0

For comparative purposes, distributions of strontium-90 and cesium-137 are presented in tables 2 and 3 for October 1965 and May through October 1966. The average strontium-90 concentrations in pasteurized milk from selected cities are presented in figure 2.

Table 3. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations October 1965 and May-October 1966

Cesium-137 (pCi/liter)	Number of stations						
	1965		1966				
	Oct.	May	June	July	Aug.	Sept.	Oct.
Under-50	54	51	56	56	56	61	62
50-99	8	11	6	6	6	1	0
100-149	0	1	1	1	1	1	1
150-199	1	0	0	0	0	0	0

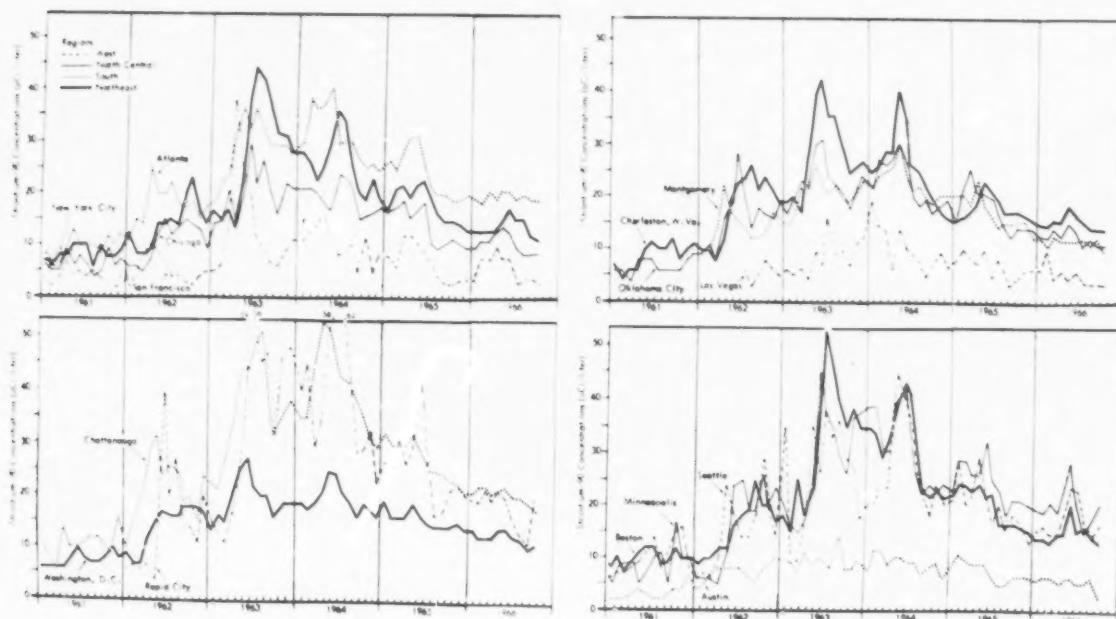


Figure 2. Strontium-90 concentrations in pasteurized milk, 1961-October 1966

2. Canadian Milk Network October 1966¹

Radiation Protection Division
Department of National Health and Welfare

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine-131, and monthly composites are analyzed for strontium-90, cesium-137, and stable calcium and

potassium. The analytical procedures were outlined in the December issue of *Radiological Health Data and Reports* (2).

The October 1966 monthly average strontium-90, cesium-137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 4. Iodine-131 and strontium-89 concentrations were below minimum detectable levels.

Table 4. Stable elements and radionuclides in Canadian whole milk, October 1966

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.14	1.4	13.5	29
Edmonton	1.13	1.4	11.6	33
Ft. William	1.12	1.5	17.5	38
Fredericton	1.16	1.4	19.9	48
Halifax	1.13	1.4	17.8	42
Montreal	1.09	1.4	12.6	27
Ottawa	1.17	1.4	9.4	21
Quebec	1.11	1.5	21.2	48
Regina	1.12	1.5	11.2	27
St. John's, Nfld.	1.08	1.4	27.3	69
Saskatoon	1.15	1.4	11.2	28
Sault Ste. Marie	1.10	1.5	16.8	42
Toronto	1.11	1.5	6.9	23
Vancouver	1.15	1.4	19.4	77
Windsor	1.12	1.4	7.0	14
Winnipeg	1.10	1.5	10.1	32
Average	1.13	1.4	14.6	37

¹ Prepared from November 1966 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

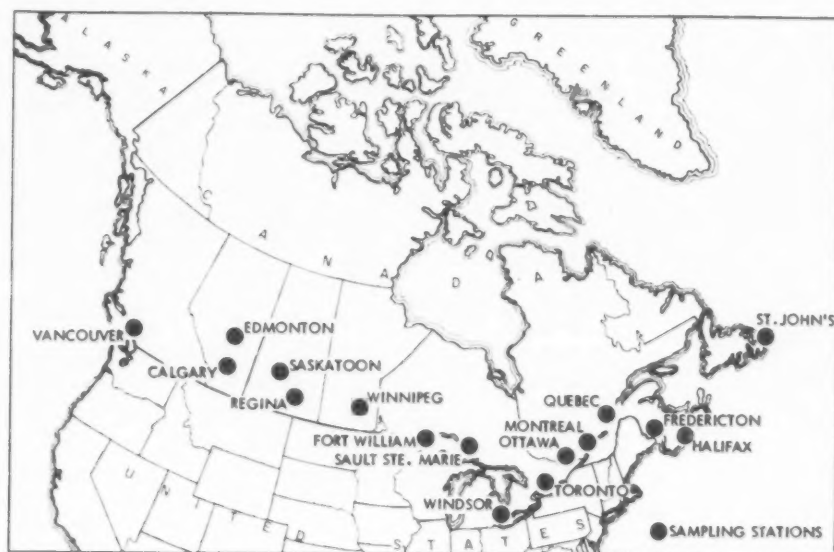


Figure 3. Canadian milk sampling stations

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3. Pan American Milk Sampling Program October 1966

*Pan American Health Organization and
U.S. Public Health Service*

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between both agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (3).

Table 5 presents stable calcium and potassium, strontium-89, strontium-90, and cesium-137 monthly average concentrations for October 1966.



Figure 4. Pan American Milk Sampling Program stations

Table 5. Stable element and radionuclide concentrations in PAHO milk, October 1966

Sampling station	Samples	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Strontium-89 (pCi/liter) *	Cesium-137 (pCi/liter)	Iodine-131 * (pCi/liter)	Barium-140 * (pCi/liter)
Chile:								
Santiago.....	4	1.12	1.63	3	8	10	70	23
Colombia:								
Bogota.....	4	1.10	1.41	3	5	9	<10	<10
Ecuador:								
Guayaquil.....	3	1.10	1.59	2	38	7	63	43
Jamaica:								
Kingston.....	1	1.09	1.50	7	<5	135	<10	<10
Monteville.....		NS						
Montego Bay.....		NS						
Venezuela:								
Caracas.....		NS						
Canal zone:								
Cristobal ^b				5		25		
Puerto Rico:								
San Juan ^b				5		15		

* Data have been corrected for decay to the date of sample collection.

^b For comparison purposes, the radionuclide concentrations at Cristobal, Canal Zone, and San Juan, Puerto Rico, are presented.

NS, no sample collected.

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STATE MILK SURVEILLANCE ACTIVITIES

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have reached a point of having comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk

surveillance activities. State milk surveillance activities are continually undergoing developmental changes at this time. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

In addition to the State milk networks presented herein, programs previously covered in *Radiological Health Data and Reports* include:

State milk network	Period reported	Last presented
California	April-June 1966	December 1966
Colorado	January 1965-June 1966	October 1966
Florida	July-September 1966	January 1966
Oklahoma	July-September 1966	January 1966
Oregon	April-June 1966	December 1966
Texas	July-September 1966	January 1966
Washington	April-June 1966	December 1966

1. Connecticut Milk Network July-September 1966

Connecticut State Department of Health

The Connecticut State Department of Health has been monitoring pasteurized milk for strontium-89 and strontium-90 since April 1960. In May 1962, the program was expanded to include the determination of gamma-ray emitting radionuclides in milk.

The sampling program is flexible in nature, providing for sampling in five areas of the State (figure 1). At the present time, weekly samples representative of milk sold in the central area of the State are collected and analyzed for strontium-89, strontium-90, and gamma-ray-emitting radionuclides. Concentrations of iodine-131 are determined as an indication of the presence of radioactivity of recent origin.

Strontium-89 and strontium-90 are determined by chemical separation. Iodine-131 and other gamma-ray-emitting radionuclides are determined by gamma-ray-scintillation spectrometry.

The monthly average concentrations of strontium-89, strontium-90, iodine-131, and cesium-137 in Connecticut pasteurized milk are presented in table 1. These results are presented graphically in figure 2.

Table 1. Radionuclide concentrations in central Connecticut milk, July-September 1966

Month	Radionuclide concentration (pCi/liter)			
	Strontium-89	Strontium-90	Iodine-131	Cesium-137
July	3	12	<10	30
August	<1	9	<10	30
September	<1	16	<10	20

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
April 1960-December 1962	May 1963
Annual summary 1963	September 1964
Annual summary 1964	May 1965
Annual summary 1965	May 1966
January-March 1966	August 1966
April-June 1966	November 1966



Figure 1. Connecticut pasteurized milk sampling areas

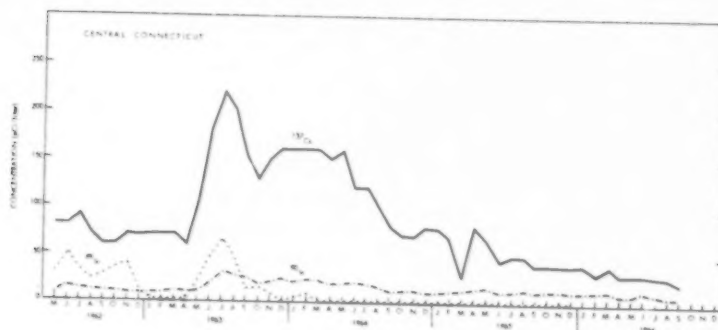


Figure 2. Radionuclide concentrations in Connecticut pasteurized milk 1962-September 1966

2. Indiana Milk Network July-September 1966

*Bureau of Environmental Sanitation
Indiana State Board of Health*

The Indiana State Board of Health began sampling pasteurized milk for radionuclide analysis in September 1961. For sampling purposes, the State was geographically divided into five major milksheds: northeast, northwest, central, southeast, and southwest (figure 3). One large dairy within each milkshed was assumed to be representative for sampling purposes.

The milk samples are analyzed monthly for strontium-89 and strontium-90. Iodine-131, cesium-137, and barium-140 are analyzed weekly in at least two of the milksheds. When iodine-131 concentrations exceed 100 pCi/liter, the sampling frequency is increased. From August 1963 to April 1966, because of the continued low concentrations of short-lived radionuclides, the sampling frequency was once a month for the northeast, southeast, and southwest milksheds.

Strontium-89 and strontium-90 concentrations in milk samples are determined by ion exchange separation (1,2) while iodine-131,

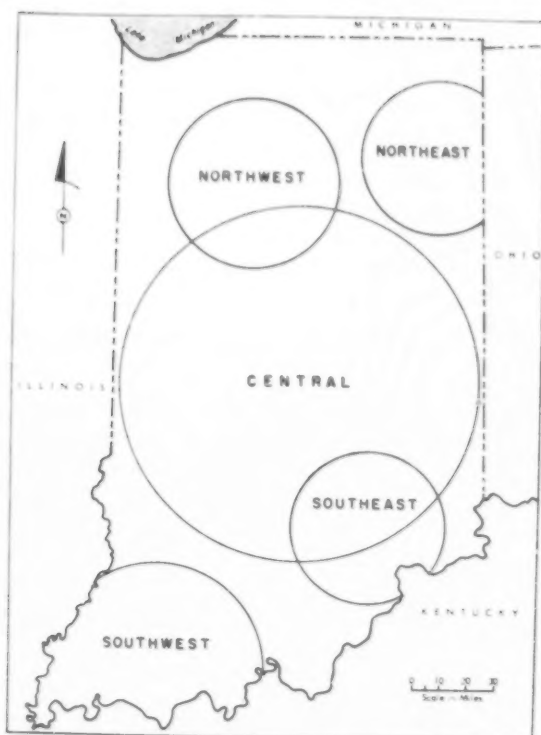


Figure 3. Indiana pasteurized milk sampling areas

cesium-137, and barium-140 are determined by gamma-ray-scintillation spectrometry (3).

The monthly radionuclide concentrations in Indiana pasteurized milk are presented by station in table 2 for July through September 1966, and reflect the mainland China atmospheric nuclear test of May 9, 1966.

Table 2. Radionuclides in Indiana milk, July-September 1966 *

Element and month	Sampling location					
	North-east	South-east	Central	South-west	North-west	Average
Calcium, g/liter						
July.....	1.18	1.21	1.20	1.17	1.18	1.19
August.....	1.00	1.13	1.11	1.16	1.11	1.12
September.....	1.43	1.32	1.35	1.38	1.35	1.37
Potassium-40, pCi/liter						
July.....	1,340	1,410	1,330	1,330	1,370	1,360
August.....	1,280	1,390	1,280	1,280	1,320	1,310
September.....	1,350	1,340	1,350	1,350	1,360	1,350
Strontium-89, pCi/liter						
July.....	5	10	10	10	15	10
August.....	0	5	5	0	5	5
September.....	0	0	0	0	0	0
Strontium-90, pCi/liter						
July.....	12	18	10	18	16	15
August.....	9	16	11	20	11	13
September.....	9	16	10	16	12	13
Cesium-137, pCi/liter						
July.....	25	25	20	20	30	25
August.....	20	25	15	20	30	20
September.....	20	15	10	15	15	15

* Iodine-131 and barium-140 concentrations were below detectable levels of 10 pCi/liter.

The monthly network average concentrations of strontium-89, strontium-90, and cesium-137 are presented graphically in figure 4. Iodine-131 and barium-140 concentrations remained below detectable levels of 10 pCi/liter during this period.

Recent coverage in *Radiological Health Data and Reports*:

Period
Annual summary 1961-1964
Annual summary 1965
January-March 1966
April-June 1966

Issue
May 1965
May 1966
August 1966
November 1966

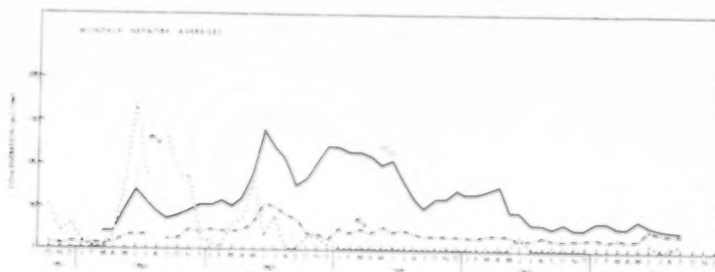


Figure 4. Radionuclide concentrations in Indiana pasteurized milk 1961-September 1966

3. Michigan Milk Network July–September 1966

*Division of Occupational Health
Michigan Department of Health*

The Michigan Department of Health began sampling pasteurized milk for radionuclide analyses in November 1962. Under this program, weekly pasteurized milk samples are collected in the seven major milk-producing areas in the State: Charlevoix, Detroit, Grand Rapids, Lansing, Marquette, Monroe, and Saginaw (figure 5). Milkshed samples are composite samples of individual dairies in proportion to the volume of sales.

Strontium-90 concentrations are determined by an ion exchange method (4). Potassium-40, iodine-131, cesium-137, and barium-lanthanum-140 concentrations are determined by gamma-ray-scintillation spectrometry (4).

Table 3 presents the monthly average radionuclide concentrations in Michigan pasteurized milk. Strontium-90 and cesium-137 concentrations are presented graphically in figure 6 to show general trends.

Previous coverage in *Radiological Health Data and Reports*:

Period

November 1962–December 1964
and annual summary 1964
Annual summary 1965
January–June 1966

Issue

September 1965
May 1966
November 1966



Figure 5. Michigan pasteurized milk network sampling locations

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Table 3. Radionuclide concentration in Michigan pasteurized milk, July-September 1966

Sampling location	Radionuclide concentrations (pCi/liter)											
	Potassium-40			Strontium-90			Iodine-131			Cesium-137		
	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept
Charlevoix	1,380	1,350	1,370	8	7	NA	<14	<14	<14	26	21	16
Detroit	1,320	1,310	1,330	4	4	NA	<14	<14	<14	18	16	11
Grand Rapids	1,320	1,300	1,350	9	6	NA	<14	<14	<14	20	21	18
Lansing	1,340	1,350	1,340	6	4	NA	<14	<14	<14	17	16	19
Marquette	1,320	1,290	1,330	17	11	NA	<14	<14	<14	75	51	35
Monroe	1,360	1,300	1,340	7	7	NA	<14	<14	<14	19	15	11
Saginaw	1,320	1,340	1,310	5	4	NA	<14	<14	<14	19	17	12
Average	1,340	1,320	1,340	8	6	NA	<14	<14	<14	29	22	16

NA, no analysis.

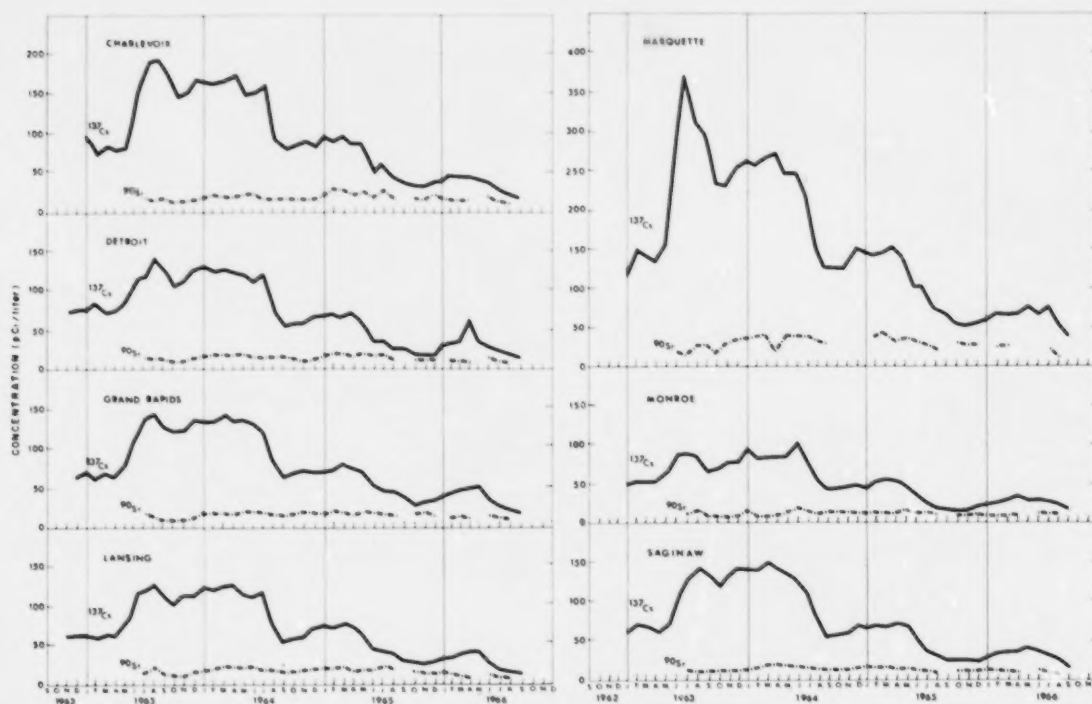


Figure 6. Radionuclide concentrations in Michigan pasteurized milk, 1962-September 1966

4. Minnesota Milk Network July-September 1966

*Division of Environmental Health
Minnesota Department of Health*

In September 1958, the Minnesota Department of Health initiated a pasteurized milk network to monitor strontium-90 concentrations. Presently, monthly samples are collected from eight sampling locations in milksheds which are geographically the same as the Minnesota health districts (figure 7). One-liter samples of processed Grade A fluid milk are collected at bottling machines in pasteurization plants. The samples are customarily collected in the cities where the Minnesota Health Department district offices are located. However, it is sometimes convenient to collect at other locations. Such samples are considered representative of the district concerned. Analyses are performed for strontium-90, iodine-131, and cesium-137 concentrations.

Strontium-90 concentrations are determined after radiochemical separation, while iodine-131 and cesium-137 concentrations are determined by gamma-ray-scintillation spectrometry. The analytical procedures are presented in the semiannual report of the Minnesota Department of Health and Rural Cooperative Power Association (5).

Strontium-90 and cesium-137 concentrations in milk are given for July through September 1966 in table 4, and are presented graphically by milkshed in figure 8 for the period July through September 1966. Iodine-131 concentrations in milk were below 10 pCi/liter for this period and are omitted from table 4.

Previous coverage in *Radiological Health Data and Reports*:

Period
November 1962-December 1964
Annual summary 1965
January-March 1966
April-June 1966

Issue
September 1965
May 1966
August 1966
November 1966

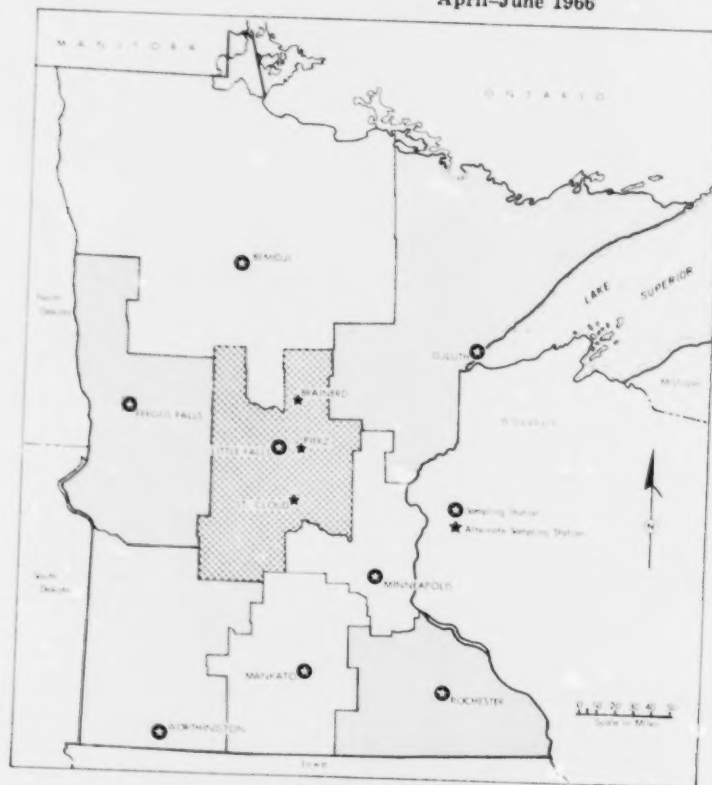


Figure 7. Minnesota milk sampling locations

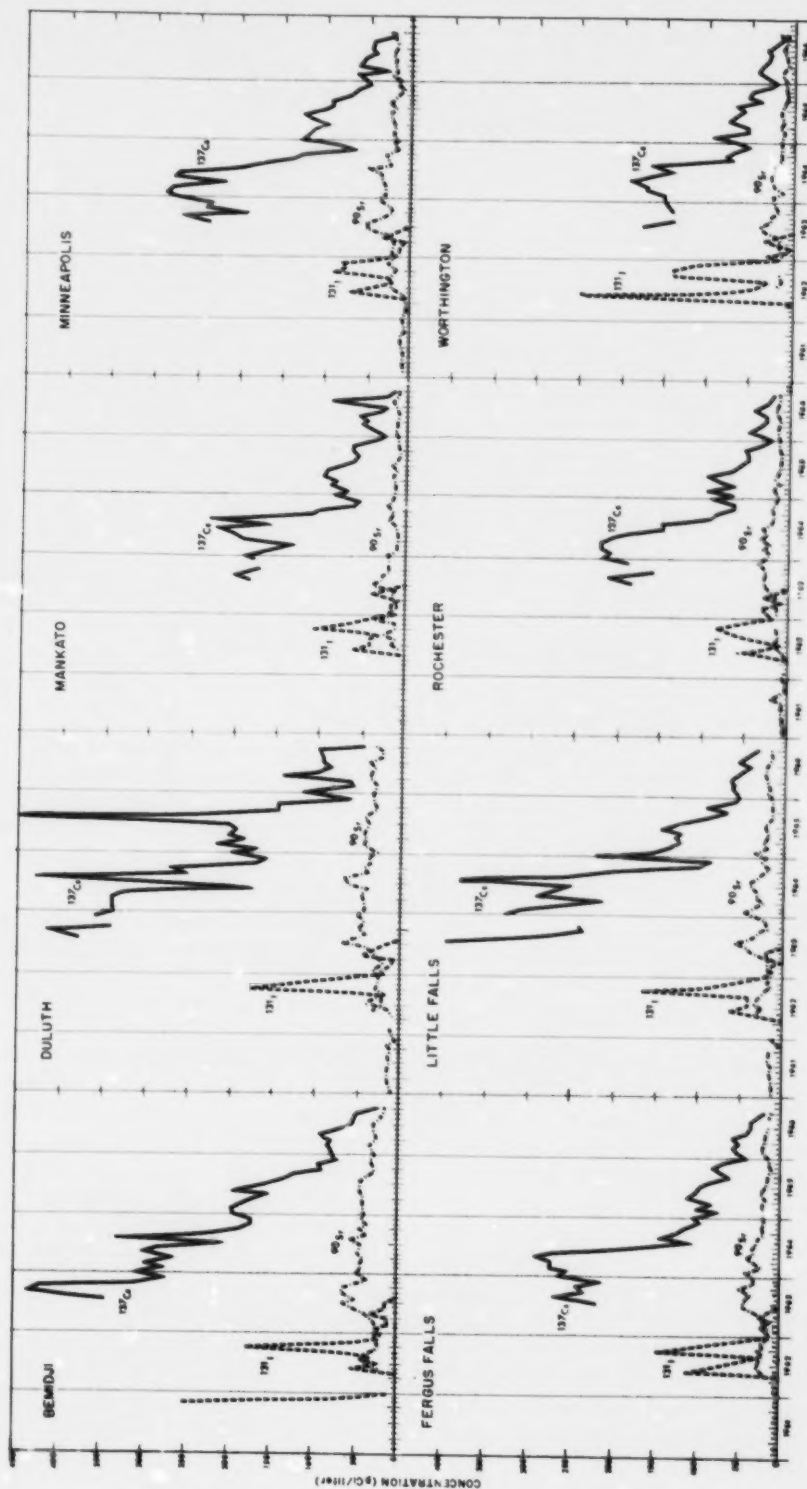


Figure 8. Radionuclide concentrations in Minnesota milk, 1951-September 1966

**Table 4. Radionuclide concentrations in Minnesota milk
July-September 1966**

Sampling location and month 1966	Radionuclide concentrations (pCi/liter)	
	Strontium-90	Cesium-137
Bemidji		
July	21	63
August	16	52
September	15	22
Mankato		
July	16	80
August	12	23
September	10	13
Rochester		
July	12	24
August	8	19
September	9	15
Duluth		
July	21	88
August	22	97
September	26	42
Worthington		
July	12	27
August	8	13
September	10	18
Minneapolis		
July	11	45
August	13	22
September	14	22
Fergus Falls		
July	NA	30
August	13	26
September	11	18
Little Falls		
July	18	59
August	15	40
September	17	29
Average		
July	16	53
August	13	22
September	14	22

NA, no analysis.

5. New York Milk Network July-September 1966

*Division of Environmental Health Services
Department of Health, State of New York*

Pasteurized milk samples collected routinely from six cities (figure 9) are analyzed for strontium-89, strontium-90, iodine-131, and barium-lanthanum-140 by the New York State Department of Health. At Buffalo, Newburgh, and Syracuse, milk samples are collected daily from processing plants, and composited weekly for radiochemical analysis. At Massena, samples are composited biweekly, while at New York

City, a milk sample representing the total milk supply for 1 day is obtained and composited weekly for analysis. The Albany sample, taken at a marketing point, is analyzed daily for iodine-131 and other gamma-ray-emitting radionuclides before being composited into a weekly sample. In the event that any sample contains iodine-131 concentrations exceeding 100 pCi/liter, increased surveillance is undertaken.

Gamma-ray-emitting radionuclides in milk are determined by scintillation spectrometry and the application of a matrix method of analysis (6) to the resultant spectral data.

The analytical procedure for determining strontium-89 and strontium-90 concentrations

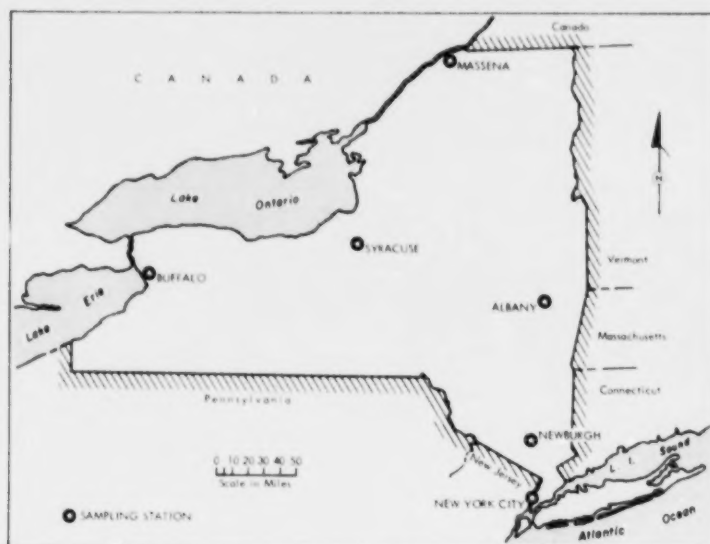


Figure 9. New York milk sampling stations

employs an ion exchange system similar to that developed by Porter and Kahn (2).

The monthly average radionuclide concentrations of strontium-89, strontium-90, iodine-131, and cesium-137 are shown in table 5 for July through September 1966. Cesium-137 and iodine-131 concentrations since September 1961 are presented graphically in figure 10.

Recent coverage in *Radiological Health Data and Reports*:

Period
July-September 1964
October-December 1964
Annual summary 1965
January-June 1966

Issue
April 1965
May 1965
May 1966
November 1966

Table 5. Radionuclide concentrations in New York milk, July-September 1966

Sampling locations	Radionuclide concentrations (pCi/liter)											
	Strontium-89			Strontium-90			Iodine-131			Cesium-137		
	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept
Albany	5	<3	<3	7	7	6	<20	<20	<20	<20	<20	<20
Ashford	4	NS	NA	15	NS	NA	<20	NS	<20	22	NS	<20
Bedford	NS	NS	NS	NS	NS	NS	<20	<20	<20	<20	<20	<20
Buffalo	<3	<3	<3	9	4	6	NS	NS	NS	NS	NS	NS
Clarktown	<3	<3	<3	6	6	7	<20	<20	<20	28	22	<20
East Otto	NA	NS	<3	NA	NS	9	<20	NS	<20	35	NS	<20
Massena	3	<3	NS	10	13	NS	<20	<20	NS	46	39	NS
Middleburg	4	<3	NA	10	9	NA	<20	<20	<20	29	<20	<20
Mount Pleasant	3	<3	<3	8	5	6	<20	<20	<20	26	<20	39
Newburgh	<3	<3	NA	10	14	NA	<20	<20	<20	21	<20	24
New York	NA	<3	<3	NA	10	11	<20	<20	<20	31	30	<20
Oyster Bay	NS	NA	<3	NS	NA	10	NS	<20	39	NS	47	27
Syracuse	NA	<3	<3	NA	<3	8	<20	<20	<20	<20	<20	<20
Yaphank	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Yorkshire	NA	NS	NA	NA	NS	NA	<20	NS	<20	22	NS	28
Yorktown	NA	NA	<3	NA	NA	20	<20	<20	<20	39	34	22
Average	3	<3	<3	9	8	9	<20	<20	<20	25	21	<20

NS, no sample
NA, no analysis

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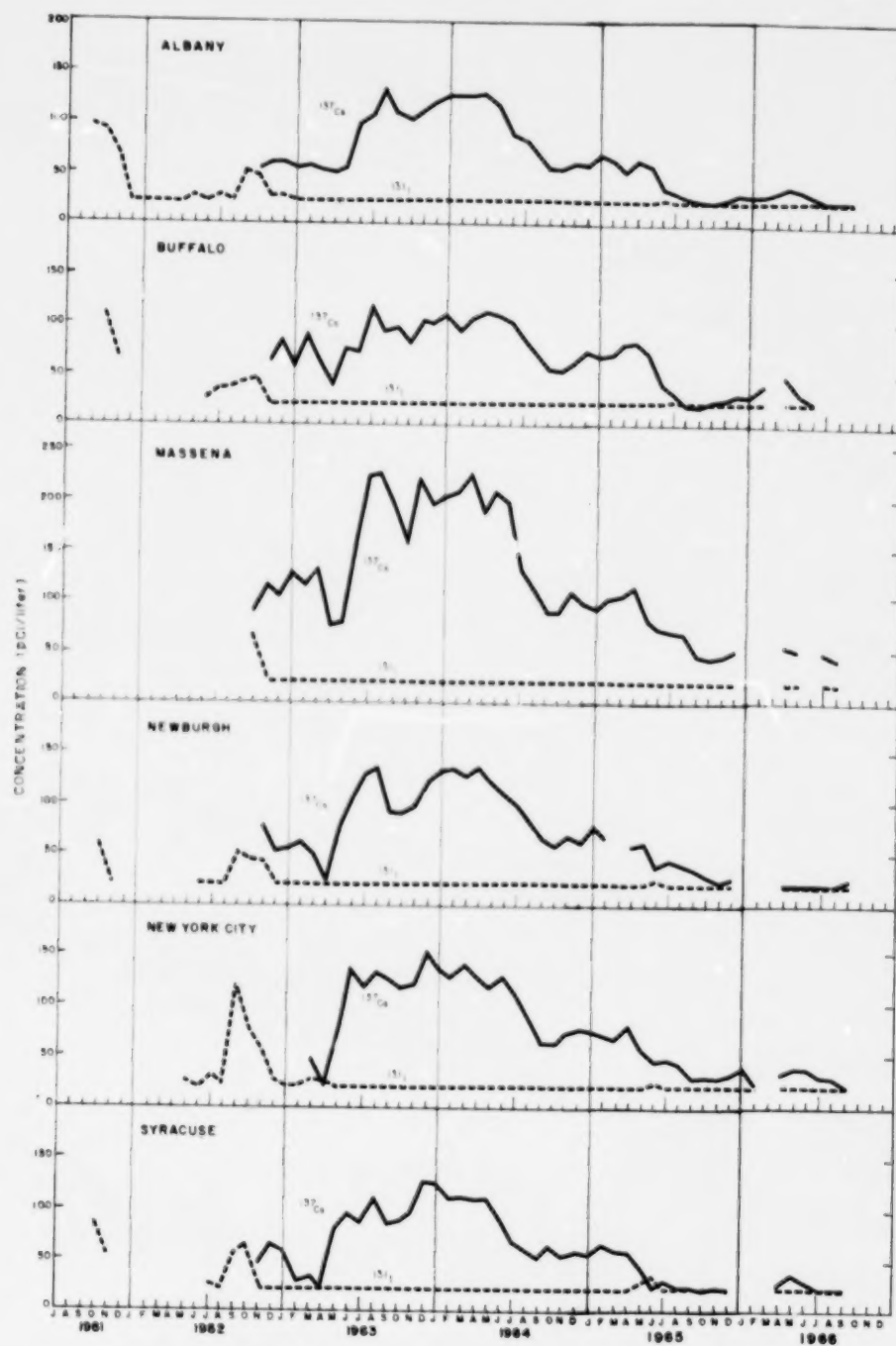


Figure 10. Radionuclide concentrations in New York milk, 1961-September 1966

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6. Pennsylvania Milk Network July-September 1966

Bureau of Environmental Health
Pennsylvania Department of Health

Samples of pasteurized milk are routinely collected from 10 major milk consumption areas throughout Pennsylvania (figure 11). Two samples per week are collected in Philadelphia and Pittsburgh, while weekly composite samples are collected from the other eight stations. At each sampling location sub-samples are collected from the major dairies supplying the area and are composited in proportion to the amount of milk processed by each dairy. This composite is then sent to the Radiation Laboratory of the Division of Occupational Health in Harrisburg where the weekly samples are combined for monthly analyses. Strontium-90 analyses have been carried out since April 1963.

The monthly average potassium-40, strontium-90, iodine-131, and cesium-137 concentrations in pasteurized milk are given in table 6. For comparative purposes, strontium-90, iodine-131, and cesium-137 concentrations are presented graphically in figure 12.

The chemical separation technique for strontium-90 is based on an ion exchange method described by Porter and Kahn (2).

Table 6. Radionuclide concentrations in Pennsylvania milk
July-September 1966

Sampling location and month 1966	Radionuclide concentrations (pCi/liter)			
	Potassium-40	Strontium-90	Iodine-131	Cesium-137
Altoona				
July	880	9.0	<10	22.0
August	NA	15.0	NA	NA
September	NA	11.5	NA	NA
Dauphin				
July	798	15.0	<10	20.5
August	NA	15.0	NA	NA
September	NA	10.5	NA	NA
Erie				
July	862	20.5	11	32.0
August	835	15.5	14	33.0
September	NA	11.5	NA	NA
Kingston				
July	883	27.5	<10	38.0
August	802	21.0	ND	33.0
September	NA	16.0	NA	NA
Lancaster				
July	864	10.7	<10	25.0
August	800	11.5	10	20.0
September	NA	10.0	NA	NA
Philadelphia				
July	876	17.5	<10	22.5
August	849	13.0	10	21.0
September	NA	4.5	NA	NA
Pittsburgh				
July	848	24.0	<10	28.5
August	884	20.0	10	25.0
September	NA	15.0	NA	NA
Reading				
July	840	15.0	<10	19.0
August	NA	11.0	NA	NA
September	NA	4.5	NA	NA
Williamsport				
July	738	14.5	28.5	38.5
August	NA	16.5	NA	NA
September	NA	10.5	NA	NA
York				
July	859	9.5	<10	26.0
August	NA	13.0	NA	NA
September	NA	10.0	NA	NA
Average				
July	846	16.4	<10	27.2
August	834	15.2	<10	26.4
September	NA	11.4	NA	NA

NA, no analysis
ND, not detectable

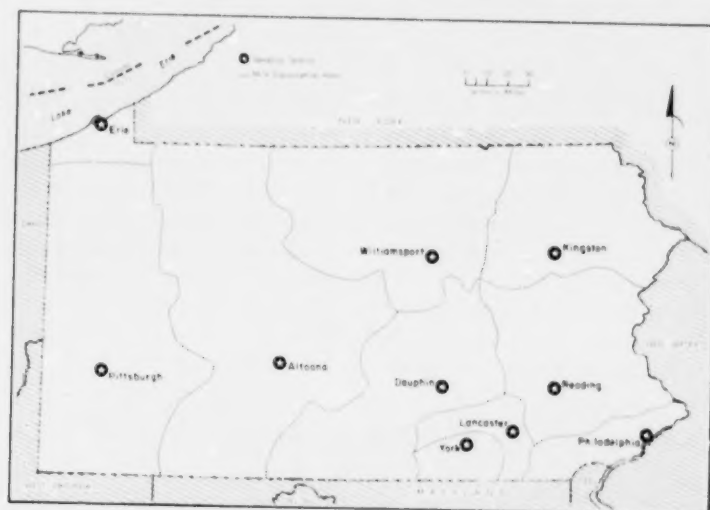


Figure 11. Pennsylvania pasteurized milk network sampling locations

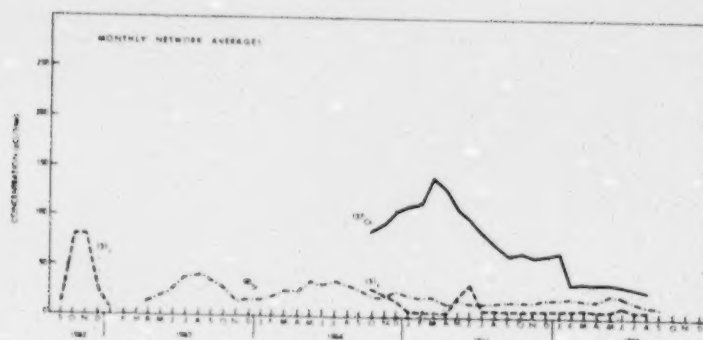


Figure 12. Radionuclide concentrations in Pennsylvania pasteurized milk 1962-September 1966

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
August-September 1964	February 1965
Annual summary 1964	June 1965
Annual summary 1965	May 1966
January-March 1966	August 1966
April-June 1966	November 1966

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- (1) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Determination of strontium-90 in milk by an ion-exchange method. *Anal Chem* 33:1306-1308 (September 1961).
- (2) PORTER, C., and B. KAHN. Improved determinations of strontium-90 in milk by an ion-exchange

method. *Anal Chem* 36:676-678 (March 1964).

- (3) INDIANA STATE BOARD OF HEALTH, BUREAU OF ENVIRONMENTAL SANITATION. Indiana milk network, April-June 1965. *Radiol Health Data* 6:612-614 (November 1965).
- (4) MICHIGAN DEPARTMENT OF HEALTH. Michigan milk network, November 1962-December 1964. *Radiol Health Data* 6:487-492 (September 1965).
- (5) MINNESOTA DEPARTMENT OF HEALTH and RURAL COOPERATIVE POWER ASSOCIATION. Survey of environmental radioactivity, January-June 1965. COO-615-17 (August 1965).
- (6) KAHN, B., G. K. MURTHY, C. PORTER, G. R. HAGEE, G. J. KARCHES, and A. S. GOLDIN. Rapid methods for estimating fission product concentrations in milk, PHS Publication No. 999-R-2. Copies available on request from Public Inquiries Branch, PHS, U.S. Department of Health, Education, and Welfare, Washington, D.C. 20201 (March 1963).

FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in routine operation and reported periodically include: (1) the Public Health Service's Institutional Total Diet Sam-

pling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are listed below:

Program	Period reported	Last presented
California Diet	January-April 1966	January 1967
Connecticut Diet	January-June 1965	February 1966
Institutional Diet, PHS	April-June 1966	January 1967
Tri-City Diet, HASL	February-April 1966	December 1966
Teenage Diet, FDA	February-November 1965	August 1966

Section II. Water

The Public Health Service, the Federal Water Pollution Control Administration, and other federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and of specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values in treated water or dissolved solids fractions of raw surface water with the Public Health Service Drinking Water Standards (1). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (2-4), set the upper limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3

pCi/liter and 10 pCi/liter, respectively. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the guides recommended by FRC for control action. In the known absence¹ of strontium-90 and alpha emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when more complete analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the Radiation Protection Guides. Surveillance data from a number of federal and State programs are published periodically to show current and long-range trends. Water programs previously reported in *Radiological Health Data and Reports* are listed below.

¹ Absence is taken to mean a negligibly small fraction of the specific limits of 10 pCi/liter and 3 pCi/liter for strontium-90 and unidentified alpha-particles emitters, respectively.

Program	Period reported	Last presented
California Water Sampling Program	July-December 1965	November 1966
Coast Guard Water Sampling Program	1965	November 1966
Colorado River Basin Sampling Network	1962-1964	November 1965
Drinking Water Analysis Program	1962	October 1965
Florida Water Sampling Program	1964	November 1965
Kentucky Water Sampling Program	May 1963-June 1964	March 1965
Lower Columbia River Radiological Survey in Oregon	August 1963-July 1964	October 1965
Minnesota Surface Water Sampling Program	July-December 1965	July 1966
New York Surface Water Sampling Program	June-December 1965	June 1966
North Carolina Water Sampling Program	1964	November 1965
Radiostromium in Tap Water, HASL	May and July-November 1965	June 1966
Washington Surface Water Sampling Program	July 1964-June 1965	May 1966

REFERENCES

- (1) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).
- (2) FEDERAL RADIATION COUNCIL. Radiation protection guidance for federal agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

- (3) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).
- (4) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, AUGUST 1966

Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of Interior

The monitoring of levels of radioactivity in surface waters of the United States was started in 1957 as a part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha-particle and beta-particle analyses. The radioactivity associated with dissolved solids provides a rough indication of the levels that would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported quarterly. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical

procedures was published in the June 1966 issue of *Radiological Health Data and Reports*.

Complete data and exact sampling locations are published in annual compilations and are available on request (1-6).

Special note is made when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or sus-



Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, August 1966

pended solids for all stations of the Water Pollution Surveillance System will be attempted. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During both July and August the following stations showed alpha radioactivity in excess of 15 pCi liter on either dissolved or suspended solids:

Arkansas River: Coolidge, Kans.
Rio Grande: Laredo, Tex.
South Platte River: Julesburg, Colo.

Shiprock, N. Mex., on the San Juan River, and Plattsmouth, Nebr., on the Platte River, showed increases of suspended alpha radioactivity in excess of 15 pCi/liter. Laredo, Tex., on the Rio Grande, showed beta radioactivity on suspended solids in excess of 150 pCi/liter. This was due entirely to high quantities of suspended solids.

On the Columbia River at Pasco, Wash., only the last sample of the month showed appreciable beta radioactivity in the dissolved solids. The Hanford reactors were not operating for most of this period.

Table 1. Radioactivity in raw surface waters, August 1966

Station	Average beta radioactivity (pCi/liter)			Average alpha radioactivity (pCi/liter)			Station	Average beta radioactivity (pCi/liter)			Average alpha radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total		Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:							Missouri River:						
Cedar Hill, N. Mex.	3	7	10	1	1	2	Williston, N. Dak.	6	16	22	1	2	3
Arkansas River:							Bismarck, N. Dak.	7	15	22	2	3	5
Coolidge, Kans.	42	26	68	11	11	22	St. Joseph, Mo.	35	16	51	11	3	14
Ponca City, Okla.	41	12	53	14	0	14	North Platte River:						
Achafalaya River:							Henry, Nebr.	5	23	28	<1	10	10
Morgan City, La.	3	10	13	<1	1	1	Ohio River:						
Bear River:							Cairo, Ill.	2	6	8	0	0	0
Preston, Idaho	0	20	20	0	5	5	Pend Oreille River:						
Big Horn River:							Albion Falls Dam,						
Hardin, Mont.	3	9	12	0	3	3	Idaho	<1	3	3	0	<1	<1
Clearwater River:							Platte River:						
Lewiston, Idaho	1	2	3	0	0	0	Plattsmouth, Nebr.	106	14	120	20	1	21
Clinch River:							Potomac River:						
Clinton, Tenn.	0	3	3	0	0	0	Washington, D.C.	1	6	7	0	0	0
Kingston, Tenn.*	7	17	24	0	0	0	Rainy River:						
Colorado River:							Baudette, Minn.	2	11	13	0	0	0
Loma, Colo.	20	18	38	3	7	10	Red River, North:						
Parker Dam, Calif.							Grand Forks,						
Ariz.	1	26	27	0	11	11	N. Dak.	5	22	27	1	2	3
Columbia River:							Red River, South:						
Wenatchee, Wash.	0	2	2	0	0	0	Alexandria, La.	3	16	19	0	0	0
Pasco, Wash.*	5	51	56	0	0	0	Rio Grande:						
Clatskanie, Ore.	0	5	5	0	1	1	El Paso, Tex.	65	14	79	13	3	16
Connecticut River:							Laredo, Tex.	333	19	352	85	5	90
Enfield Dam, Conn.	1	4	5	0	0	0	San Joaquin River:						
Coosa River:							Vernalis, Calif.	9	9	18	2	5	7
Rome, Ga.	1	3	4	0	0	0	San Juan River:						
Cumberland River:							Shiprock, N. Mex.	137	15	152	45	4	49
Cheatham Lock,							Savannah River:						
Tenn.	1	4	5	0	0	0	Port Wentworth,						
Delaware River:							Ga.*	2	11	13	<1	2	2
Philadelphia, Pa.	4	7	11	0	0	0	Snake River:						
Great Lakes:							Payette, Idaho	1	12	13	<1	4	4
Duluth, Minn.	0	3	3	0	0	0	Wawawai, Wash.	1	7	8	0	1	1
Green River:							South Platte River:						
Dutch John, Utah	1	16	17	0	3	3	Julesburg, Colo.	13	47	60	1	30	31
Hudson River:							Susquehanna River:						
Poughkeepsie, N.Y.	0	5	5	0	0	0	Conowingo, Md.	2	4	6	0	0	0
Illinois River:							Tennessee River:						
Peoria, Ill.	2	9	11	0	1	1	Chattanooga, Tenn.	4	5	9	0	0	0
Grafton, Ill.	2	10	12	0	0	0	Wabash River:						
Kansas River:							New Harmony, Ind.	1	7	8	0	1	1
DeSoto, Kans.	6	18	24	3	2	5	Yellowstone River:						
Klamath River:							Sidney, Mont.	25	17	42	5	3	8
Keno, Ore.	<1	9	9	0	0	0	Maximum	333	51	352	85	30	90
Maumee River:							Minimum	0	2	2	0	0	0
Toledo, Ohio	0	8	8	0	0	0							
Mississippi River:													
St. Paul, Minn.	1	12	13	0	0	0							
E. St. Louis, Ill.	7	14	21	2	2	4							
New Roads, La.	2	10	12	1	1	2							
New Orleans, La.	1	11	12	0	1	1							

* Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides common to all stations.

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Section III. Air and Deposition

RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to the analysis of gross beta radioactivity. Although such data are insufficient to assess total human radiation exposure, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range

trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the results from the above networks was performed by Lockhart and Patterson (1) in 1962. In addition to the programs presented in this issue, the following programs were previously covered in *Radio-logical Health Data and Reports*.

<u>Network</u>	<u>Period</u>	<u>Issue</u>
HASL Fallout Network	July-December 1965	September 1966
HASL 80th Meridian Network	Calendar year 1965	January 1967

1. Radiation Surveillance Network October 1966

National Center for Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples at 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Maryland, for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta radio-

activity made by the station operators prior to submission of the samples for laboratory analysis. When high radioactivity levels in air are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (2). A detailed description of the sampling and analytical procedures was presented in the November 1966 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air and deposition by precipitation during October 1966. Time profiles of gross beta radioactivity in air for eight RSN stations are shown in figure 2. Fresh fission products, at very low levels, were identified on the samples collected at Agana, Guam, on October 28 and 29, 1966. Gamma-ray analyses of the remaining 305 RSN air samples were negative.



Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, August 1966

Table 1. Gross beta radioactivity in surface air and precipitation, October 1966

Station location		Number of samples		Air surveillance (gross beta radioactivity, pCi/m ³)			Last profile in RHD & R	Precipitation	
		Air	Pptn	Maximum	Minimum	Average *		Total depth (mm)	Total gross beta radioactive deposition (nCi/m ²)
Ala:	Montgomery	31	4	<0.10	<0.10	<0.10	Nov 66	126	<25
Alaska:	Adak	28		<0.10	<0.10	<0.10	June 66	(b)	
	Anchorage	19	3	<0.10	<0.10	<0.10	Dec 66	18	<4
	Attu Island	15		<0.10	<0.10	<0.10	July 66	(b)	
	Fairbanks	22	6	<0.10	<0.10	<0.10	Jan 67	7	<1
	Juneau	19	15	<0.10	<0.10	<0.10	Feb 67	294	<59
	Kodiak	2		<0.10	<0.10	<0.10	May 66	(b)	
	Nome	6		<0.10	<0.10	<0.10	Sept 66	(b)	
	Pt. Barrow	28		<0.10	<0.10	<0.10	Aug 66	(b)	
	St. Paul Island	20		<0.10	<0.10	<0.10	Oct 66	(b)	
Ariz:	Phoenix	26		0.17	<0.10	<0.10	Feb 67	(b)	
Ark:	Little Rock	31	6	<0.10	<0.10	<0.10	Dec 66	(b)	55
Calif:	Berkeley	20		<0.10	<0.10	<0.10	May 66	(b)	
	Los Angeles	20	1	<0.10	<0.10	<0.10	Sept 66		2
C. Z:	Ancon	16		<0.10	<0.10	<0.10	Feb 67	(b)	
Colo:	Denver	28		0.11	<0.10	<0.10	May 66		2
Conn:	Hartford	30	7	<0.10	<0.10	<0.10	Jan 67		72
Del:	Dover	21		<0.10	<0.10	<0.10	Nov 66	(b)	
D.C.:	Washington	28	5	<0.10	<0.10	<0.10	Aug 66		96
Fla:	Jacksonville	28	9	<0.10	<0.10	<0.10	Dec 66		107
	Miami	27	7	<0.10	<0.10	<0.10	Jan 67		170
Gu:	Atlanta	(*)	1				Oct 66		25
Guam:	Agaña	31		0.22	<0.10	<0.11	Nov 66	(b)	
Hawaii:	Honolulu	30	2	<0.10	<0.10	<0.10	July 66		58
Idaho:	Boise	30	4	<0.10	<0.10	<0.10	July 66		32
Ill:	Springfield	30		<0.10	<0.10	<0.10	Aug 66		58
Ind:	Indianapolis	30	6	<0.10	<0.10	<0.10	Oct 66		54
Iowa:	Iowa City	31	4	<0.10	<0.10	<0.10	Feb 67		57
Kans:	Topeka	31	2	<0.10	<0.10	<0.10	Dec 66		7
Ky:	Frankfort	31	3	<0.10	<0.10	<0.10	Aug 66		21
La:	New Orleans	31	7	<0.10	<0.10	<0.10	Aug 66		99
Maine:	Augusta	30	8	<0.10	<0.10	<0.10	Sept 66		130
	Presque Isle	21	7	<0.10	<0.10	<0.10	Feb 67		58
Md:	Baltimore	20	5	<0.10	<0.10	<0.10	Jan 67		44
	Rockville	14		<0.10	<0.10	<0.10	July 66	(b)	
Mass:	Lawrence	31	5	<0.10	<0.10	<0.10	Nov 66		79
	Winchester	31	5	<0.10	<0.10	<0.10	June 66		55
Mich:	Lansing	30	6	<0.10	<0.10	<0.10	July 66		20
Minn:	Minneapolis	20	4	<0.10	<0.10	<0.10	Nov 66		96
Miss:	Jackson	31	3	<0.10	<0.10	<0.10	Sept 66		49
Mo:	Jefferson City	30	7	<0.10	<0.10	<0.10	Oct 66		79
Mont:	Helena	31	5	0.16	<0.10	<0.10	June 66		19
Neb:	Lincoln	19	1	0.31	<0.10	<0.11	Oct 66		1
Nev:	Las Vegas	27		<0.10	<0.10	<0.10	Jan 67	(b)	
N.H.:	Concord	18		<0.10	<0.10	<0.10	Aug 66	(b)	
N.J.:	Trenton	31	4	<0.10	<0.10	<0.10	Sept 66		34
N. Mex:	Sante Fe	29	2	<0.10	<0.10	<0.10	June 66		7
N.Y.:	Albany	19	6	<0.10	<0.10	<0.10	Oct 66		56
	Roseton	24		<0.10	<0.10	<0.10	Feb 67	(b)	
	New York	31		<0.10	<0.10	<0.10	June 66		96
N.C.:	Gastonia	31	7	<0.10	<0.10	<0.10	Feb 67		19
N. Dak:	Bismarck	31	3	<0.10	<0.10	<0.10	Aug 66		10
Ohio:	Cincinnati	20		<0.10	<0.10	<0.10	Nov 66	(b)	
	Columbus	29	4	<0.10	<0.10	<0.10	Sept 66		35
	Painesville	29	6	<0.10	<0.10	<0.10	Jan 67		40
Okla:	Oklahoma City	31	1	<0.10	<0.10	<0.10	July 66		1
	Ponca City	31	2	<0.10	<0.10	<0.10	Jan 67		21
Ore:	Portland	31	13	<0.10	<0.10	<0.10	Oct 66		67
Pa:	Harrisburg	31	2	<0.10	<0.10	<0.10	Oct 66		53
P.R.:	San Juan	30	8	0.23	<0.10	<0.11	Sept 66		124
R.I.:	Providence	24	4	<0.10	<0.10	<0.10	July 66		82
S.C.:	Columbia	26	3	<0.10	<0.10	<0.10	June 66		66
S. Dak:	Pierre	29	3	<0.10	<0.10	<0.10	Feb 67		16
Tenn:	Nashville	31	6	<0.10	<0.10	<0.10	July 66		77
Tex:	Austin	31	5	<0.10	<0.10	<0.10	Nov 66		29
	El Paso	28		<0.10	<0.10	<0.10	Aug 66	(b)	
Utah:	Salt Lake City	31	3	<0.10	<0.10	<0.10	Sept 66		43
Vt:	Barre	31	7	<0.10	<0.10	<0.10	Dec 66		44
Va:	Richmond	30	6	<0.10	<0.10	<0.10	Dec 66		103
Wash:	Seattle	31	11	<0.10	<0.10	<0.10	Dec 66		76
	Spokane	28		<0.10	<0.10	<0.10	Nov 66	(b)	
W. Va:	Charleston	30	8	<0.10	<0.10	<0.10	June 66		38
Wis:	Madison	31	3	<0.10	<0.10	<0.10	Dec 66		46
Wyo:	Cheyenne	29	2	<0.10	<0.10	<0.10	Jan 67		4
Network summary		1,931	274	0.31	<0.10	<0.10		57	<12

* The monthly average is calculated by weighting the individual sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes if 10 percent or more samples from a station contain <0.10 pCi/m³, a less-than sign is placed before the average.
 (b) No precipitation sample collected.
 * No report received.

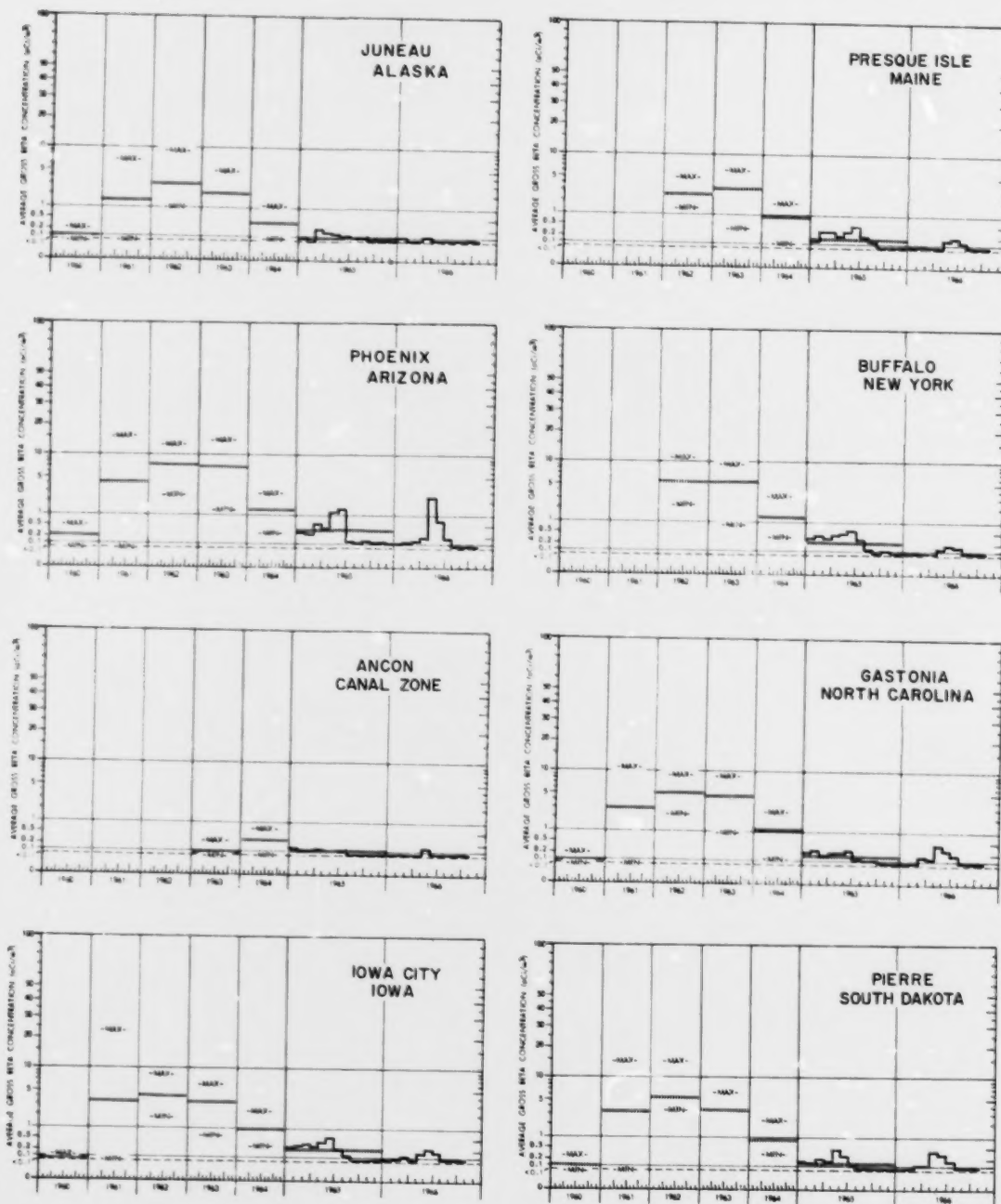


Figure 2. Monthly and yearly profiles of beta radioactivity in air, Radiation Surveillance Network, 1960-October 1966

2. Canadian Air and Precipitation Monitoring Program, October 1966¹

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport (figure 3). Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports by the Department of National Health and Welfare (3-7).

A summary of the sampling procedures and methods of analysis was presented in the November 1966 issue of *Radiological Health Data and Reports*.

¹ Prepared from information and data in the November 1966 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for October 1966 are presented in table 2. Specific radionuclide data are presented in table 3.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, October 1966

Station	Air surveillance				Precipitation measurements	
	Number of samples	Activity, pCi/m ³			Average concentrations (pCi/liter)	Total deposition activity (nCi/m ²)
		Maximum	Minimum	Average		
Calgary.....	31	0.1	0.0	0.0	28	0.4
Coral Harbour.....	31	0.1	0.0	0.0	NS	NS
Edmonton.....	31	0.0	0.0	0.0	22	0.2
Ft. Churchill.....	18	0.0	0.0	0.0	38	0.8
Ft. William.....	31	0.1	0.0	0.0	14	1.1
Fredericton.....	11	0.1	0.0	0.0	15	1.1
Goose Bay.....	31	0.1	0.0	0.0	7	1.1
Halifax.....	31	0.1	0.0	0.0	14	1.2
Inuvik.....	31	0.0	0.0	0.0	9	0.2
Montreal.....	30	0.1	0.0	0.0	19	0.8
Moosonee.....	31	0.1	0.0	0.0	12	1.3
Ottawa.....	31	0.1	0.0	0.0	28	0.7
Quebec.....	31	0.1	0.0	0.0	16	1.0
Regina.....	31	0.1	0.0	0.0	47	0.3
Resolute.....	29	0.1	0.0	0.0	23	0.2
St. John's, Nfld.....	31	0.1	0.0	0.0	7	0.8
Saskatoon.....	31	0.1	0.0	0.0	34	0.4
Sault Ste. Marie.....	31	0.1	0.0	0.0	16	1.7
Toronto.....	31	0.1	0.0	0.0	23	0.3
Vancouver.....	31	0.1	0.0	0.0	7	0.9
Whitehorse.....	31	0.0	0.0	0.0	6	0.2
Windsor.....	30	0.1	0.0	0.0	24	0.9
Winnipeg.....	20	0.1	0.0	0.0	49	1.0
Yellowknife.....	31	0.1	0.0	0.0	17	0.7
Network summary.....		0.1	0.0	0.0	21	0.8

NS, no sample



Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program October 1966

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F., Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff

members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high-volume samplers.

After each 20-hour-sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron.

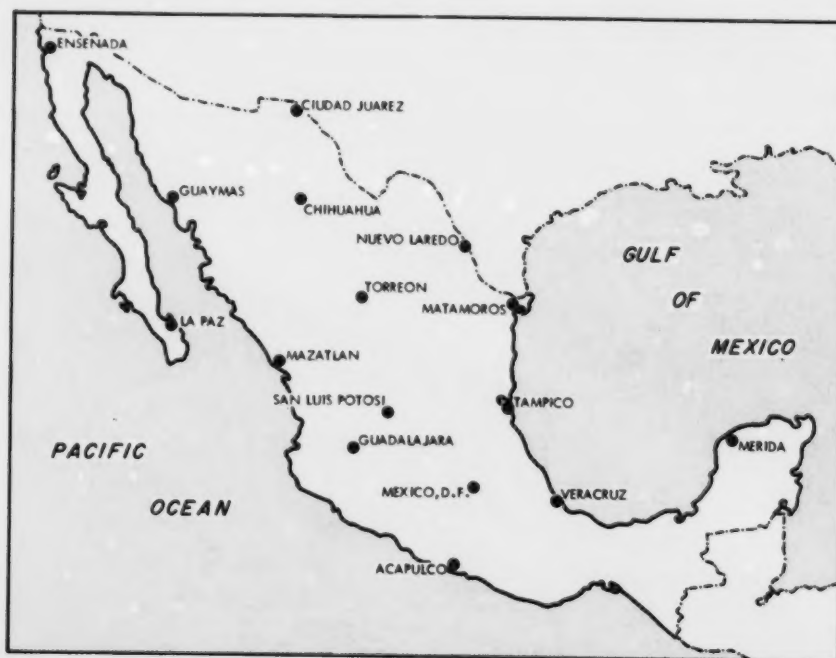


Figure 4. Mexican air sampling station locations

The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of eight samples per month were needed to get a reliable average radioactivity at each station (8).

The maximum, minimum, and average fission product beta radioactivity concentrations in surface air during October 1966 are presented in table 4.

Table 4. Mexican gross beta radioactivity of airborne particulates, October 1966

Station	Number of samples	Gross beta radioactivity, pCi/m ³		
		Maximum	Minimum	Average
Acapulco.....	7	0.1	0.1	0.1
Chihuahua.....	10	0.2	0.1	0.1
Ciudad Juárez.....	15	0.2	<0.1	0.1
Ensenada.....	15	0.6	<0.1	0.1
Guaymas.....	NS			
Guadalajara.....	10	0.1	<0.1	0.1
La Paz.....	18	0.1	<0.1	0.1
Matamoros.....	8	0.5	<0.1	0.1
Mazatlán.....	7	0.3	<0.1	0.1
Mérida.....	15	0.6	<0.1	0.1
México, D. F.....	4	0.1	<0.1	0.1
Nuevo Laredo.....	9	0.5	<0.1	0.2
San Luis Potosí.....	6	0.1	<0.1	<0.1
Tampico.....	6	0.1	<0.1	<0.1
Torreón.....	17	0.5	<0.1	0.2
Vera Cruz.....	15	0.2	<0.1	0.1

NS, no sample collected; station temporarily shut down.

4. Pan American Air Sampling Program October 1966

Pan American Health Organization and U.S. Public Health Service

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the National Center for Radiological Health, PHS, and are identical with those employed

for the Radiation Surveillance Network. The air sampling station positions are shown in figure 5.

Fresh fission products were identified during October in the samples in table 5. The October 1966 air-monitoring results from the participating countries are given in table 6. Levels were considerably higher than in September.

Decay indices of the various samples indicate that most of the gross beta radioactivity was probably from either the French test on September 24, 1966, or the French test on October 4, 1966.

Table 5. Fresh fission products in PAHO air samples
October 1966

Location	Dates, October 1966	Maximum activity at time of collection (pCi/m ³)	Date of maximum activity
Peru: Lima.....	* 1, 5, 13-20.....	31.37	18
Chile: Santiago.....	8-24, 26, 29-31.....	13.12	11
Venezuela: Caracas.....	b 24, 26-31.....	0.83	31
Argentina: Buenos Aires.....	1-6, 7-19, 21-27, 30, 31.....	19.91	1
Jamaica: Kingston.....	14, 17.....	0.53	14
West Indies: Trinidad.....	* 3, 4, 10-14, 26, 27.....	2.15	10
Columbia: Bogotá.....	d 5, 6, 14-21, 26-31.....	0.80	17
Ecuador: Guayaquil.....	* 1-3, 5-13, 15-31.....	6.15	17

* No sample received for October 6-15, 30, 31.

b No sample received for October 1-20.

c No sample received for October 29-31.

d No sample received for October 7.

e No sample received for October 14.

Table 6. PAHO gross beta radioactivity in surface air
October 1966

Station location	Number of samples	Gross beta radioactivity (pCi/m ³)		
		Maximum	Minimum	Average *
Argentina: Buenos Aires.....	26	19.91	<0.10	3.07
Chile: Santiago.....	31	13.12	<0.10	<1.62
Columbia: Bogotá.....	24	0.80	<0.10	<0.30
Ecuador: Guayaquil.....	28	6.15	<0.10	1.85
Jamaica: Kingston.....	22	0.53	<0.10	<0.12
Peru: Lima.....	14	31.37	0.94	9.56
Venezuela: Caracas.....	7	0.83	<0.10	<0.47
West Indies: Trinidad.....	19	2.15	<0.10	<0.57
Pan American summary.....	171	31.37	<0.10	<2.19

* The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If 10 percent or more of the samples from a station contain <0.10 pCi/m³, a less-than sign is placed before the average.



Figure 5. Pan American Air Sampling Program stations

5. Plutonium in Airborne Particulates July-September 1966

*National Center for Radiological Health
Public Health Service*

The Radiation Surveillance Network (RSN) of the National Center for Radiological Health, Public Health Service, located at Rockville, Maryland, is continuing routine analysis for plutonium in airborne particulates. These analyses were initiated during 1965 as part of the

mission to establish, maintain, and operate a national surveillance network to measure radioactivity in the environment.

Air filters from 11 RSN stations are analyzed for plutonium. Each of the daily filters is counted for gross beta radioactivity and for gamma-ray emitters by gamma-ray scintillation spectrometry 4 to 5 days after collection. For plutonium analysis, a monthly composite is made of one-half of the individual sample from each station. Each composite, representing 10,000 to 20,000 cubic meters of air,

is analyzed by gamma-ray scintillation spectrometry prior to the plutonium analysis.

Details of the method of collection and radiochemical analyses were presented in an earlier report (9). Results for July through September 1966 are given in table 7.

Table 7. Plutonium in airborne particulates, July-September 1966 *

Station location	Plutonium radioactivity concentration in air (pCi/1,000 m ³)		
	July	August	September
Alaska: Anchorage.....	0.088	0.049	0.057
Ariz: Phoenix.....	0.068	0.045	0.061
Colo: Denver.....	0.056	0.075	0.056
Hawaii: Honolulu.....	0.084	0.037	0.025
La: New Orleans.....	0.107	0.067	0.036
Md: Rockville.....	0.153	0.066	0.062
N. Y: Buffalo.....	0.143	0.073	0.084
N. C: Gastonia.....	0.114	0.051	0.052
S. Dak: Pierre.....	0.106	0.076	0.047
Tex: Austin.....	0.069	0.047	0.042
Wash: Seattle.....	0.050	0.046	0.027

* Plutonium includes plutonium-238, plutonium-239, and plutonium-240.

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Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections.

Included are such data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

STRONTIUM-90 IN HUMAN BONE, JANUARY-MARCH 1966¹

*National Center for Radiological Health
Public Health Service*

To obtain data on the concentration of strontium-90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. The target population includes children and young adults up to 25 years of age. Since strontium-90 in measurable amounts has been present in the global environment for not much more than a decade, and since major calcium accretion ceases by age 17 or 18, persons over 25 years old are of limited interest in the program. This has been confirmed by analyses of selected samples of people in older age groups, the results having shown their bone strontium-90 content to be low and age-independent (1).

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age.

Most specimens received to date have been vertebrae and ribs. Efforts to collect long bones

for comparison of results with British data have not been successful.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory of the National Center for Radiological Health, at Winchester, Mass. Sample collection and preparation are explained elsewhere (2). Strontium-90 is measured by TBP extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium-90 content is then calculated from the yttrium-90 activity (3). For the purpose of maintaining analytical reproducibility, "blind" duplicate analyses are performed on 10 to 20 percent of the samples. To further check and maintain analytical accuracy synthetic "bone ash" samples (calcium phosphate spiked with strontium-90) are analyzed periodically and cross-check analyses are carried out quarterly in cooperation with the AEC Health and Safety Laboratory.

The analytical results for strontium-90 in individual bones from persons dying during the first quarter (January-March) of 1966, along with other pertinent data (place of residence, sex, bone type, and cause of death), are presented in table 1 in order of increasing age within each geographical sampling region. These regions are indicated in figure 1. Re-

¹ Period during which death or surgical procedure occurred.

Table 1. Strontium-90 in human bone, deaths and surgical procedures during January-March 1966

Sampling region and state of residence	Sex	Bone type *	Age at death ^b (years)	Cause of death	Strontium-90, pCi/g of:		
					Ash $\pm 2\sigma$ error	Calcium	Bone
Northeast:							
N.Y.	F	V	1	Neuroblastoma	1.53 $\pm$ 0.17	4.33	0.12
Maine	M	V	2	Hyperkalemia	2.97 $\pm$ 0.21	8.12	0.29
R.I.	M	V.R.S.	3	Congenital heart disease	1.76 $\pm$ 0.22	4.97	0.11
Mass.	M	V	3	Thermal burns	1.64 $\pm$ 0.14	4.51	0.16
Mass.	M	V	3	Acute leukemia	1.44 $\pm$ 0.14	4.04	0.13
Mass.	F	V	4	Acute leukemia	1.29 $\pm$ 0.14	3.75	0.08
Vt.	M	V	4	Mitral stenosis	1.23 $\pm$ 0.17	3.48	0.12
N.Y.	F	V	4	Wilms's tumor	1.58 $\pm$ 0.16	4.22	0.13
N.Y.	M	V	7	Acute leukemia	0.71 $\pm$ 0.09	1.95	0.06
N.Y.	F	V	7	Thrombocytopenic purpura	1.30 $\pm$ 0.10	3.48	0.15
(*)	M	V	7	Acute leukemia	1.40 $\pm$ 0.13	3.95	0.14
Maine	F	V	8	Acute leukemia	1.29 $\pm$ 0.10	3.60	0.12
Pa.	M	V	8	Head injury	0.72 $\pm$ 0.09	1.96	0.05
Mass.	M	V	9	Congenital heart disease	0.77 $\pm$ 0.08	2.08	0.08
R.I.	F	V.R.S.	9	Astrosyoma	0.88 $\pm$ 0.08	2.35	0.13
N.Y.	M	V	10	Hemophilia	0.97 $\pm$ 0.13	2.64	0.09
Mass.	F	V	10	Cystic fibrosis	0.99 $\pm$ 0.09	2.69	0.10
Mass.	F	V	11	Acute leukemia	1.20 $\pm$ 0.10	3.27	0.13
N.Y.	F	V	11	Myeloblastic leukemia	0.93 $\pm$ 0.08	2.57	0.08
N.Y.	M	V	11	Brain tumor	1.09 $\pm$ 0.14	3.14	0.14
Mass.	M	V	12	Asphyxia	1.21 $\pm$ 0.09	3.24	0.15
N.Y.	F	V.R.S.	14	Glomerulonephritis	1.15 $\pm$ 0.12	3.20	0.12
N.J.	M	V	15	Muscular dystrophy	0.64 $\pm$ 0.08	1.71	0.06
N.Y.	M	V	17	Acute leukemia	0.75 $\pm$ 0.09	2.00	0.10
Mass.	M	V	18	Asphyxiation	0.99 $\pm$ 0.08	2.57	0.12
Pa.	M	R	19	Hydrocephalus	0.55 $\pm$ 0.06	1.41	0.07
N.Y.	M	V	19	Gunshot wound of chest	0.93 $\pm$ 0.08	1.57	0.15
Pa.	M	V	21	Carcinoma of testes	0.51 $\pm$ 0.07	1.30	0.08
Mass.	M	V	21	Gunshot wound of buttock	0.82 $\pm$ 0.08	2.11	0.11
N.Y.	M	V	21	Auto accident	0.80 $\pm$ 0.10	2.12	0.10
Pa.	M	V	23	Sympathicoblastoma	0.78 $\pm$ 0.07	2.07	0.11
Mass.	F	V	25	Gunshot wound of neck	0.66 $\pm$ 0.08	1.71	0.10
(*)	F	V	25	Cerebral laceration	0.66 $\pm$ 0.07	1.72	0.10
Southeast:							
Ga.	M	V	3	Thermal burns	1.67 $\pm$ 0.19	4.66	1.13
Md.	F	V	3	Stab wounds of neck	1.97 $\pm$ 0.19	4.93	0.17
Md.	F	V	5	Stab wounds of neck	1.33 $\pm$ 0.15	3.55	0.11
Md.	F	V	6	Thermal burns	1.23 $\pm$ 0.12	3.47	0.13
Md.	M	V	12	Drowning	0.68 $\pm$ 0.07	1.79	0.07
Md.	M	V	14	Gunshot wound of chest	0.90 $\pm$ 0.07	2.37	0.13
Md.	M	V	17	Head injury	1.28 $\pm$ 0.09	3.38	0.18
Md.	F	V	17	Laceration of aorta	0.73 $\pm$ 0.08	1.88	0.11
Md.	M	V	17	Electrocution	0.96 $\pm$ 0.08	2.49	0.13
Ky.	F	V	21	Barbiturate overdose	1.03 $\pm$ 0.06	2.71	0.15
Md.	M	V	21	Mitral stenosis	0.95 $\pm$ 0.09	2.52	0.13
Md.	M	V	21	Gunshot wound of chest	0.79 $\pm$ 0.08	2.02	0.13
Md.	M	V	22	Gunshot wound of head	0.62 $\pm$ 0.09	1.55	0.08
Md.	M	V	23	Subdural hematoma	0.59 $\pm$ 0.06	1.53	0.06
Md.	M	V	23	Acute alcoholism	0.92 $\pm$ 0.09	2.34	0.15
Ky.	M	V	24	Partial spinal cord transection	0.69 $\pm$ 0.09	1.76	0.13
Central:							
Mich.	F	V	1	Tetralogy of Fallot	1.72 $\pm$ 0.21	4.94	0.14
Ohio	M	V	1	Fanconi's syndrome	1.54 $\pm$ 0.13	3.97	0.11
Minn.	M	V	3	Drowning	1.01 $\pm$ 0.12	2.71	0.11
Wis.	M	V	3	Craniocharyngoma	1.64 $\pm$ 0.15	4.70	0.15
Ohio	M	V	3	Acute leukemia	1.47 $\pm$ 0.16	4.03	0.11
Minn.	F	V	3	Acute lymphoblastic leukemia	1.37 $\pm$ 0.17	3.83	0.10
Wis.	F	V	3	Pneumonitis	0.81 $\pm$ 0.10	2.25	0.08
Wis.	M	V	6	Tetralogy of Fallot	0.73 $\pm$ 0.07	2.01	0.07
Wis.	F	V	7	Aplastic anemia	0.77 $\pm$ 0.07	2.03	0.08
Wis.	F	V	8	Portal hypertension	1.11 $\pm$ 0.16	3.05	0.11
Ohio	M	V	8	Abdominal injuries	1.14 $\pm$ 0.13	2.11	0.17
Minn.	M	V	8	Rhabdomyosarcoma	1.44 $\pm$ 0.14	3.92	0.14
Minn.	M	V	8	Auto accident	0.69 $\pm$ 0.08	2.01	0.06
Wis.	M	V	10	Cerebellar tumor	0.86 $\pm$ 0.12	2.30	0.07
Ohio	F	V	10	Bilateral lobular pneumonia	1.42 $\pm$ 0.10	3.79	0.15
Wis.	F	V	12	Malnutrition	0.68 $\pm$ 0.13	1.88	0.05
Ohio	F	V	13	Asphyxiation	1.00 $\pm$ 0.07	2.59	0.18
Ohio	F	V	13	Acute cerebellar hemorrhage	1.22 $\pm$ 0.08	3.18	0.18
Minn.	M	V	15	Brain injuries	0.76 $\pm$ 0.06	1.97	0.14
Ohio	M	V	18	Diabetic acidosis	0.55 $\pm$ 0.06	1.38	0.08
Ohio	F	V	19	Brain injury	0.55 $\pm$ 0.06	1.41	0.13
Ohio	F	V	20	Anaphylaxis	0.67 $\pm$ 0.12	1.70	0.14
Mich.	M	V	21	Rheumatic heart disease	0.51 $\pm$ 0.07	1.32	0.07
Wis.	M	V	22	Ependymoma	1.13 $\pm$ 0.15	3.10	0.09
Ohio	M	V	22	Meningeal sarcoma	0.85 $\pm$ 0.08	2.22	0.08
Delta:							
La.	F	V	4	Acute leukemia	1.59 $\pm$ 0.23	4.40	0.11
La.	M	V.R	10	Sickle cell anemia	2.39 $\pm$ 0.16	6.53	0.24
La.	M	V.R	14	Head injury	1.08 $\pm$ 0.07	2.86	0.15
La.	M	V.R	16	Lobar pneumonia	1.03 $\pm$ 0.09	2.80	0.15
(*)	M	V	17	Chronic glomerulonephritis	1.91 $\pm$ 0.10	5.05	0.30
(*)	M	V	17	(*)	0.79 $\pm$ 0.06	2.08	0.12

See footnotes at end of table.

Table 1. Strontium-90 in human bone, deaths and surgical procedures during January-March 1966—Continued

Sampling region and state of residence	Sex	Bone type ^a	Age at death ^b (years)	Cause of death	Strontium-90, pCi/g of:		
					Ash $\pm 2\sigma$ error	Calcium	Bone
Northwest:							
Alaska	M	R	13	Surgical procedure	1.86 $\pm$ 0.29	4.77	0.29
Alaska	F	R	17	Surgical procedure	1.26 $\pm$ 0.17	3.25	0.53
Alaska	F	R	18	Surgical procedure	0.79 $\pm$ 0.24	1.95	0.31
Alaska	F	R	19	Surgical procedure	0.95 $\pm$ 0.31	2.42	0.37
Southwest:							
Calif.	F	V.R.I	0	Stillbirth	0.48 $\pm$ 0.07	1.36	0.04
(*)	F	V	1	(*)	0.57 $\pm$ 0.11	1.83	0.06
(*)	M	V	1	(*)	0.70 $\pm$ 0.12	1.25	0.06
Tex.	M	V	19	Bullet wound of brain	0.69 $\pm$ 0.08	1.77	0.09
Tex.	F	V	20	Cerebral encephalopathy	0.64 $\pm$ 0.06	1.68	0.06

^a Type of bone: V, vertebrae; R, rib; I, ilium; S, sternum.
^b Age given as of last birthday prior to death.
^c Information not yet available.

ported values are given in picocuries of strontium-90 per gram of ash (the primary determination), per gram of calcium (for comparison with other data and for purposes of model development), and per gram of bone (as a rough indication of dose). Two-sigma counting errors are reported for the ash concentration.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (2-4).

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Figure 1. Geographical regions for human bone sampling

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational

Safety in directives published in the AEC Manual.¹

Summaries of the environmental radioactivity data follow for the Hanford Atomic Products Operation, Pinellas Peninsula Plant, Savannah River Plant, and Shippingport Atomic Power Station.

¹ Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contains essentially the standards published in the AEC Manual and are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

1. Hanford Atomic Products Operation Calendar Year 1965²

*Battelle Memorial Institute
Richland, Washington*

The evaluation of results obtained from the Hanford environmental surveillance program for 1965 indicates that most of the environmental radiation dose received by the majority of persons living in the neighborhood of the Hanford project was due to natural sources and worldwide fallout rather than to Hanford operations.

Of the low-level wastes that are released to the environment from the Hanford plants, neutron-induced radionuclides present in reactor cooling water discharged to the Columbia River continued to be the source of greatest potential radiation dose to people in the environs. The primary pathways of exposure from this source are drinking water derived from the river, consumption of fish and waterfowl which inhabit the river, and foodstuffs grown on land irrigated with water pumped from the Columbia River downstream from Hanford.

Residents of Richland were supplied throughout the year with drinking water from the Columbia River. The radiation dose from

drinking this water was estimated to be about 7 percent of the appropriate limit. The gastrointestinal tract is the limiting organ for the mixture of radionuclides present in drinking water pumped from the Columbia River. In Pasco and Kennewick, which are further downriver, the estimated doses from drinking water were, respectively, about 2.5 percent and <0.5 percent of the limit for the GI tract. The only persons who received radiation doses attributable to Hanford greater than those that resulted from the drinking water were the people who ate local fish or waterfowl.

The highly unlikely but plausible combination of circumstances that would result in the greatest dose to an individual from the radionuclides released by the Hanford plant is postulated as:

- (1) the consumption of some 200 meals per year of fish caught downstream from the reactors,
- (2) the consumption of meat and milk from cattle pastured, and fruit and vegetable grown, on irrigated farms in the Riverview District, and
- (3) the consumption of drinking water from the Pasco system.

An individual with such habits could conceivably ingest enough radioactive materials of Hanford origin (mostly phosphorus-32) to provide an intake of about 12 percent of the maximum permissible rate of intake (MPRI)

² Summarized from Pacific Northwest Laboratory, Evaluation of Radiological Conditions in the Vicinity of Hanford for 1965, BNWL-316, September 1966.

specified by the International Commission on Radiological Protection (ICRP) for individuals in the general population, with bone as the critical organ. The resultant annual dose to the GI tract and whole body would then have been about 90 and 40 mrem, respectively, during 1965.

Iodine-131 in the Hanford environs remained at very low concentrations in 1965. The Chinese nuclear test on May 14 caused a brief increase in iodine-131, but concentrations soon returned to the low levels experienced during most of 1965. The postulated "maximum" annual dose from iodine-131 to the thyroid of a small child amounted to only about 4 percent of the radiation protection guide recommended

for individuals by the Federal Radiation Council.

The Hanford plant³ is located in a semiarid region of southeastern Washington State, where the average annual rainfall is about 16 cm (6 in.). This section of the State has a sparse covering of natural vegetation primarily suited for grazing, although large areas near the project have gradually been put under irrigation during the past few years. The plant site (figure 1) covers an area of about 1,300 km² (500 square miles). The Columbia River

³ Operated during 1965 for the Atomic Energy Commission by the Battelle-Memorial Institute; Douglas-United Nuclear, Inc., and the General Electric Company.

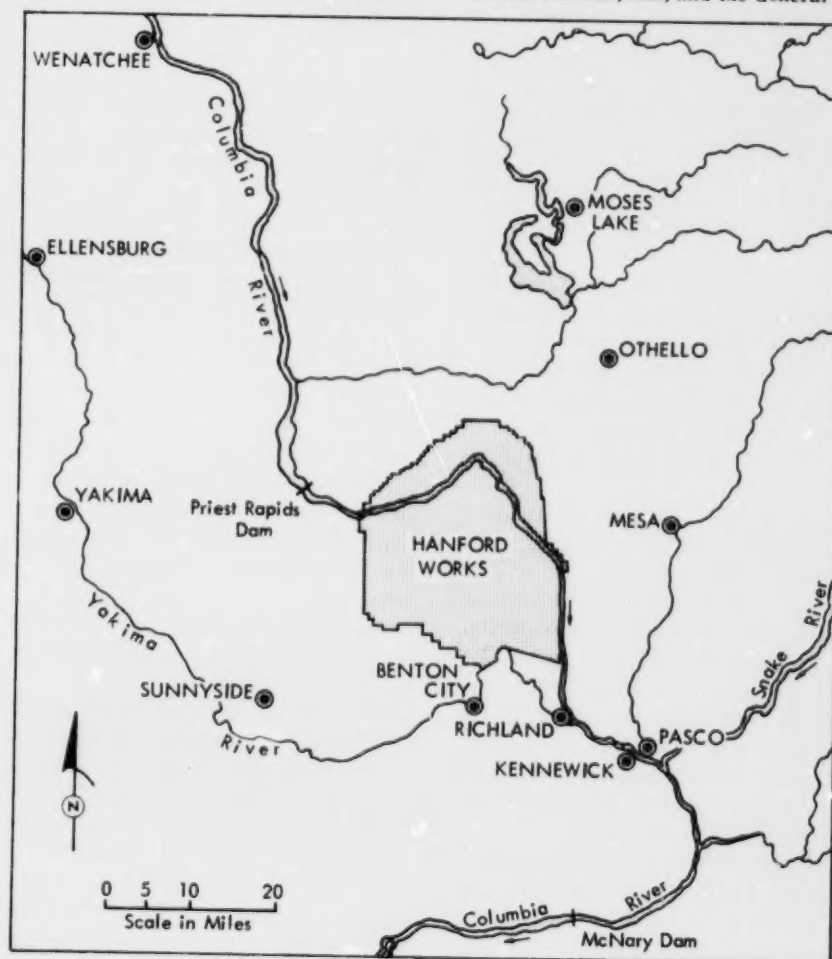


Figure 1. Hanford project environs

flows through the northern edge of the project and forms part of the eastern boundary. Near the plant production sites, the prevailing winds are from the northwest with strong drainage and cross winds causing distorted flow patterns. The meteorology of the region is typical of desert areas with frequent strong inversions occurring at night and breaking during the day to provide unstable and turbulent conditions.

The populated area of primary interest is the Tri-Cities (Richland, Pasco, and Kennewick) situated on the Columbia River directly downstream from the plant. Smaller communities in the vicinity are Benton City, West Richland, Mesa, and Othello; and these together with the surrounding agricultural area, bring the total population near the plant to about 80,000 people.

During the course of operation, various radioactive wastes are generated by the several plant facilities. High-level wastes are concentrated and retained in storage within the project boundaries. Controlled releases of low-level wastes, for which concentration and storage is not feasible, are made to the ground. Practices governing radioactive waste disposal at the Hanford Plant are described in the Hearings on Industrial Radioactive Waste Disposal held by the Joint Congressional Committee on Atomic Energy in 1959 (1).

It is the purpose of this report to present an evaluation of the combined off-project effects of the radioactive-waste-disposal practices of all Hanford contractors. Radiation protection practices, including the effects of radioactive waste disposal, are governed by AEC Manual Chapters 0524 and RL 0524 (2). The section to which this evaluation is addressed stipulates that radioactivity in effluents released to uncontrolled areas shall not result in a radiation dose to individuals exceeding 0.5 rem/yr to the whole body or gonads or 1.5 rem/yr to the thyroid or GI tract.

The significance of bone seekers such as phosphorus-32 and strontium-90 requires special consideration and treatment because the rate of intake of phosphorus-32 has not been specifically studied by the Federal Radiation Council (FRC) (3) in relation to a dose-equivalent for the bone or bone marrow.

Where the FRC does not provide direct guid-

ance, they suggest that ICRP-NCRP (National Committee on Radiation Protection and Measurement) dosimetry methods be used (4,5). The ICRP values are used as a reference base, because the ICRP-NCRP recommendations imply a more conservative rate of intake for phosphorus-32. Rather than introduce additional confusion associated with dose-equivalents for bone derived by different techniques, the data for bone seekers have been expressed in terms of a maximum permissible rate of intake (MPRI).

The MPRI is taken as the maximum permissible concentration (MPC) in water for a given radionuclide, as recommended by the ICRP for persons in the neighborhood of controlled areas, multiplied by the rate of water intake as defined for the standard man. This amounts to one-tenth of the MPC for continuous occupational exposure multiplied by intake rates of 2.2 liters/day or 800 liters/yr (for annual estimates). In the case of phosphorus-32 the MPRI is 16 $\mu\text{Ci/yr}$.

The radiological units used throughout most of this report are mrems (dose-equivalent). For the nuclides of interest at Hanford, and the organs for which radiation doses (in mrad) and dose-equivalents (mrems) are calculated, the units rad and rem are numerically equal.

Included in this report are two types of measurements which are not necessarily relevant to dose evaluations. These are the concentrations of radionuclides in the Columbia River and concentration of iodine-131 in cattle thyroids which serve as trend indicators and as support for data used in dose calculations.

All of Hanford's production reactors use Columbia River water for cooling. At the older reactors, some elements present in the cooling water are transformed into radionuclides during the single pass through the reactors. In addition, radioactive materials formed on the surfaces of fuel elements and process tubes are eventually carried away by the cooling water to the river. H and F reactors were shut down permanently on April 21, 1965, and June 25, 1965, respectively.

In contrast with the older production reactors, the N reactor uses recirculating demineralized water as a primary coolant. Only a very small amount of radionuclides generated

in auxiliary systems, such as the control rod cooling water, are released directly to the river.

Many of the radionuclides formed in reactor cooling water are short-lived and decay rapidly after formation. In addition to radioactive decay, some fraction of most radionuclides is removed from the river water by sedimentation and by uptake by aquatic organisms. Also present in the river are radionuclides contributed by fallout from nuclear weapons testing.

Samples of river water were collected above the production areas at Vernita Ferry and below the areas at the Richland and Pasco water plant intakes, at McNary Dam, the Dalles Dam, and Bonneville Dam. Where possible, cumulative sampling equipment was installed and provided a more representative sample than the periodic grab samples obtained in the past. This cumulative sampling technique, however, makes it impractical to calculate the amounts of very short-lived nuclides; these must still be measured from grab samples. The average concentration of radionuclides measured routinely at Richland, Pasco, and Bonneville Dam are shown in table 1.

Table 1. Annual average radioactivity in Columbia River water, 1965

Radioactivity	Activity concentration (pCi/liter)		
	Richland	Pasco	Bonneville Dam
Total beta.....	12/couunts/min.ml	(*)	(*)
RE + Y ^b	730	(*)	(*)
Sodium-24.....	3,100	(*)	(*)
Phosphorus-32.....	140	87	23
Chromium-51.....	7,000	4,100	1,700
Copper-64.....	2,500	(*)	(*)
Zinc-65.....	180	160	70
Arsenic-76.....	1,000	(*)	(*)
Strontium-90.....	1	(*)	(*)
Iodine-131.....	10	7	3
Neptunium-239.....	1,600	390	(*)

* Insufficient sampling data to provide a meaningful annual average.
^b Rare earths plus yttrium.

Measurements on traverses across the river at Richland indicate a slightly nonuniform distribution of the longer-lived radiosotopes at this cross-section. Entries of the Yakima River some 16 km (10 miles) above Pasco and of the Snake River some 58 km (30 miles) above McNary Dam slightly influence the distribution of radionuclides at these two points.

The magnitude of the influence varies with seasonal changes in the flow rate of the tributaries. Bonneville Dam is approximately 490 km (240 miles) below the Hanford reactors and represents the farthest downstream location where river water is routinely sampled for Hanford's environmental surveillance program.

The seasonal variation in flow rate of the Columbia River markedly affects the quantity of water available for dilution of reactor effluent released to the river. Also affected by the flow rate is the time required for a specific volume of water to move from one location to another. The annual average transport rate of selected radionuclides past the Bonneville Dam is given in table 2.

Table 2. Annual average transport rate past Bonneville Dam of selected radionuclides, 1962-1965

Radionuclide	Transport rate (Ci/day)			
	1962 *	1963 *	1964	1965
Phosphorus-32.....	13	12	12	11
Chromium-51.....	650	860	860	800
Zinc-65.....	29	28	44	49

* Rate of transport at Vancouver, Washington.

An estimate of the inventory of these radionuclides which exist in the ocean may be calculated by assuming an equilibrium between the rate of addition through the river and the rate of decay in the ocean. A constant rate of entry into the ocean equivalent to that indicated by the 1965 Bonneville Dam measurements would imply an inventory of about 230 curies of phosphorus-32, 32,000 curies of chromium-51, and 17,000 curies of zinc-65.

Radionuclides in drinking water

The city of Richland is the first community downstream from the Hanford reactors that uses the Columbia River as a source of drinking water supply. Pasco and Kennewick, a few miles farther downstream, also use the Columbia River as a source of drinking water. Continuous potable water samples were collected at the Richland water plant, and periodic samples were collected at Pasco and Kennewick. All of these samples were analyzed for the important individual radionuclides. The results of analyses of drinking water from these three cities are summarized in table 3.

Table 3. Annual average concentration of radioactivity measured in drinking water, 1965

Radioactivity	Radioactivity concentration (pCi/liter)		
	Richland	Pasco	Kennewick
Total beta.....	6.7 counts/ min-ml	2.4 counts/ min-ml	0.39 counts/ min-ml
RE + Y *	80	27	(b)
Sodium-24.....	2,300	710	80
Phosphorus-32.....	100	28	10
Chromium-51.....	7,200	3,600	1,400
Copper-64.....	1,000	190	50
Zinc-65.....	100	70	<15
Arsenic-76.....	410	100	16
Strontium-90.....	1	1	(b)
Iodine-131.....	8	6	<2
Neptunium-239.....	1,600	760	60

* Rare earths plus yttrium.

(b) Insufficient data to provide a meaningful annual average.

The concentrations of short-lived radionuclides in the water at the time it is consumed are less than shown in table 3 because there is a significant transport time between the water plant and most consumers. The transport time may vary from hours to days depending upon the location of the customers on the distribution system and the water demand.

The calculated annual average dose to the GI tract and whole body and the percent MPRI for bone from sustained consumption of drinking water throughout the year at the three cities are presented in table 4.

Table 4. Calculated annual dose for selected organs from routine ingestion of drinking water, 1965 *

Location	Whole body (mrem)	GI tract (mrem)	Bone (percent of MPRI)	Thyroid (small child, 0.4 liter/day) (mrem)
Richland.....	2.5	35	6.8	19
Pasco.....	<1	13	0.3	15
Kennewick.....	<1	1	<0.1	<5

* Here and elsewhere in this report where a dose (mrem) from an ingested nuclide is expressed, the determination is made from parameters used by the ICRP to translate dose rates into maximum permissible concentrations for drinking water. In most cases, the estimated annual intakes of individual radionuclides were multiplied by conversion factors derived from the ICRP parameters and published by Vennart and Minski (9).

Note: The "standard man" average intake rate of 1.2 liter/day was used in this calculation (4).

The GI tract dose of Richland and Pasco residents was significantly lower in 1965 than in the past years (6,7).

This is primarily attributed to the permanent shutdown of the three Hanford reactors.

An unusual release of radioactive materials occurred on September 29, 1965, from the Plutonium Recycle Test Reactor (8). The minor

effects of this release are included in the annual averages of drinking water data, and in the corresponding radiation doses from the consumption of drinking water.

Radionuclides in fish and waterfowl

The Columbia River is popular for sports fishing above and below the Hanford plant, and the fish that feed downstream from the reactors acquire some radionuclides from the reactor effluent. White fish are the sports fish that usually contain the greatest concentration of radioactive materials. Further, they can be caught during winter months when other sports fish are difficult to sample. For these reasons, whitefish are sampled most intensively to follow trends.

The average concentrations of phosphorus-32 and zinc-65 in whitefish sampled downstream from the reactors during 1965 were 200 pCi/g and 27 pCi/g of flesh, respectively. These concentrations were substantially lower than those observed in previous years (6,7), owing in part to the retirement of three Hanford reactors.

The quantities and kinds of fish caught by local fishermen have been estimated previously from surveys carried out by personnel of the State of Washington, Department of Game. Additional dietary data collected during 1965 did not change these estimates. Those individuals who probably ingest the largest amounts of phosphorus-32 are fishermen who claim to eat bass, crappie, perch, and catfish as often as three to five times a week. This large number of fish meals indicates an annual intake of about 40 kg (about 90 pounds) of fish. On the basis of the 40 kg of fish consumption claimed by the "maximum individual" (200 fish meals/year), the intake of phosphorus-32 during 1965 could have been approximately 1.7 μ Ci, or approximately 11 percent of the MPRI for bone as the critical organ.

Many persons have been counted in the Hanford whole-body counter, including some avid fishermen. Amounts of zinc-65 detected in these people were much less than expected on the basis of their stated consumption of fish. These results supported the findings of past

years which suggested that fishermen tend to over-estimate their fish consumption. Therefore, the actual ingestion rates of both phosphorus-32 and zinc-65 are undoubtedly substantially lower than currently postulated from the fishermen's estimates.

Migratory waterfowl, such as ducks and geese, which have utilized the Hanford section of the Columbia River and the swamps and ponds within the project boundaries may contain phosphorus-32, zinc-65, and small amounts of other radionuclides. Some of these waterfowl remain in this general area throughout the year. Seventy-five of the water fowl samples collected during 1965 had concentrations of phosphorus-32 less than 50 pCi/g of flesh (wet weight), 20 samples were above 50 pCi/g but less than 500 pCi/g, and the remaining 3 samples were over 500 pCi/g. The maximum concentration of phosphorus-32 was 950 pCi/g. However, as a potential source of this radionuclide to people, the waterfowl are of much less significance than the fish because they cannot be harvested in such large numbers by individuals and because of "dilution" by large flights of migrating birds that move through the region at the time of the year when hunting is allowed.

Radionuclides in marine organisms

Zinc-65 and phosphorus-32 are the only radionuclides in the reactor effluent that are found in sufficient abundance beyond the mouth of the Columbia River to be of radiological interest. Oysters have been found to contain higher concentrations of zinc-65 than other common seafood organisms.

Annual average concentrations of zinc-65 have decreased over the past 2 years, while phosphorus-32 concentrations have remained at about the same level during the same period of time (6,7). The average concentrations in samples taken throughout 1965 were 40 pCi/g and 4 pCi/g of zinc-65 and phosphorus-32, respectively.

Consumption of oysters containing these concentrations at the rate of one meal (230 g or about one-half pound) per week would result in an annual dose of about 5 mrem to the GI tract and 3 mrem to the whole body. These

intakes represent 0.3 percent of the MPRI for bone as the critical organ.

Radionuclides in the atmosphere

At Hanford, gaseous waste from the chemical separations facilities is released to the atmosphere through 70m-high (230 feet) stacks after most of the radioactive materials have been removed by filtration and scrubbing. These radioactive materials are primarily associated with process vessel off-gases. Ventilation air from laboratory and reactor buildings contains comparatively minor amounts of radioactive materials under normal operating conditions.

Measurements of airborne iodine-131 were made routinely at numerous locations within the Hanford reservation and around the plant perimeter. The results of iodine-131 measurements for the past few years are summarized in table 5.

Table 5. Annual average iodine-131 concentrations in the atmosphere, 1962-1965

Location	Distance from separation stacks (miles)	Iodine-131 (pCi/m ³)			
		1962	1963	1964	1965
Prosser Barricade *	14	(b)	(b)	0.02	0.03
Benton City	20	0.08	0.03	0.06	0.03
Richland	23	0.04	0.02	0.02	0.02
Pasco	32	0.08	0.02	0.01	0.03

* Installed during October 1963.

b Insufficient sampling data to provide a meaningful annual average.

The four locations listed in table 5 lie within a 45° sector southeast to south of the separations center. Such concentrations sustained in inspired air imply an annual dose to the thyroid of the "standard man" of less than 1 mrem.

Air filter sampling is maintained at several locations within the Hanford reservation and around the plant perimeter. Air filter results are not used in estimating exposure but serve to illustrate the trends in atmospheric contamination. Sudden changes in concentration are used to signal the need for shifted emphasis in other portions of the environmental monitoring program related to atmospheric contamination.

Radionuclides in milk and produce

The radioactivity found in locally grown agricultural produce can be influenced by deposition of airborne radionuclides or by irriga-

tion with river water containing reactor effluent radionuclides. The chemical separations facilities are generally the principal local source of airborne radionuclides. The closest farming area to the separations facilities is about 21 km (13 miles) away.

In addition to the radioactive materials released to the Columbia River from the Plutonium Recycle Test Reactor on September 29, 1965, (8), radioiodine and noble gases were released to the atmosphere. The minor effects of the atmospheric release are included in the annual averages of environmental sample data, and in the corresponding radiation dose estimates.

Most irrigated farms near the Hanford plant use water drawn from the Yakima River, or from the Columbia River above the project. There are, however, two small areas which regularly take water from the Columbia River downstream from the reactors for irrigation. They are the Ringold farms and the Riverview district west of Pasco, located respectively 24 and 48 km downstream from the reactors.

The principal products from the larger farm plots are hay, fruit, beef, and dairy products. This area is centered 48 km (30 miles) southeast of the chemical separations plants. Another agricultural area near the project is Benton City, located on the Yakima River about 20 miles (32 km) directly south of the separations facilities.

A comprehensive milk surveillance program maintained during 1965 included samples from local farms and dairies and from commercial supplies available to people in the Tri-Cities. The concentrations of radionuclides found in milk sold by commercial outlets were similar to that reported by the U.S. Public Health Service and the Washington State Department of Health. Milk from local farms irrigated with water drawn from the river downstream from the reactors contained phosphorus-32 and zinc-65 as well as fission products of fallout origin.

Generally, the average concentration of iodine-131 in both local and commercial milk was at or below the analytical limit of 3 pCi/liter except for a brief increase during the late spring (following the Chinese nuclear weapons test on May 14, 1965) and again during the

fall months (following a small, transient increase in the release rate of iodine-131 from a chemical separations facility during the latter part of October). The maximum concentration of iodine-131 observed in milk was 26 pCi/liter on November 9, 1965.

Dairy farms in the Ringold and Riverview area that utilize the Columbia River for irrigation of pasture land and hay fields produce milk containing both phosphorus-32 and zinc-65. During 1965 the average concentration of phosphorus-32 in milk from these farms was about 490 pCi/liter (much lower than the 1964 average of 1,600 pCi/liter) and the concentration of zinc-65 was 480 pCi/liter. The highest concentration of phosphorus-32 in milk (1,000 pCi/liter) was observed during early September, a period of heavy irrigation and rapid growth of pasture grass. Commercial milk distributed in the Tri-Cities usually does not contain phosphorus-32 and zinc-65 because it is obtained principally from areas not irrigated with Columbia River water.

Adult residents consuming milk (1 liter/day) obtained from the Ringold-Riverview area would receive an annual dose from phosphorus-32 and zinc-65 amounting to about 4 mrem to the GI tract and 2 mrem to the whole body. The intake of phosphorus-32 and zinc-65 would be equal to about 0.8 percent of the MPRI for bone. The intake of iodine-131 would have resulted in a dose of about 2 mrem to the thyroid.

Miscellaneous fresh farm produce was sampled periodically for radioanalysis during the 1965 growing season from local farms and commercial outlets. Results of these measurements were similar to those of previous years (6,7) and indicated that only small quantities of radionuclides are present in locally grown produce.

The concentrations of iodine-131 found in samples of fresh vegetables collected from local farms and markets during the period of May through September 1965 were less than or approximately equal to the analytical limit of 0.05 pCi/g. There was no significant difference noted in concentrations found in local farm produce and in produce purchased from commercial outlets. If these fresh vegetables had been consumed at the rate of 100 g/day

throughout the 5-month growing season, the average annual intake from this source would have been about 730 pCi for iodine-131. Such an intake would imply an annual dose of about 1 mrem to the thyroid of a typical adult Richland resident.

Concentrations of iodine-131 in cattle thyroids

Thyroids of cattle are collected periodically from slaughter houses in Moses Lake, Yakima, Walla Walla, Wenatchee, and Pasco, and are sent to Hanford for radioanalysis. The average concentrations measured in beef thyroids were generally at or below the analytical limit of 5 pCi/g for iodine-131 during most of 1965, except for a brief period in the late spring following the May 14, 1965, Chinese nuclear weapons test. The maximum concentration of iodine-131 in bovine thyroids was 150 pCi/g from one sample collected in November at Pasco.

External radiation

Ionization chambers are stationed on the Hanford reservation and in Richland to estimate the gamma radiation exposure from external sources. Measurements in air 1 meter above ground during 1965 averaged about 0.32 mR/day or 120 mR/yr at Hanford and about 0.30 mR/day or 110 mR/yr at Richland, somewhat lower than measured during the past 2 years (6,7). Essentially all of this exposure is from natural background and worldwide fallout from nuclear testing.

Direct radiation measurements are also made in the Columbia River at several locations with pocket-type ionization chambers submerged 0.6 to 1.5 m (2 to 5 feet) below the surface of the water. Exposure rates are higher in the river than overground because of the presence of gamma emitters (especially sodium-24) in reactor effluent. In the vicinity of Richland, the average exposure rate in the water during the months of April through October was about 2 mR/day. A person swimming or boating in the river for a total of 240 hours during the year could have received a whole-body exposure of about 20 mR.

An estimate of the external radiation exposure received by people that fish from the shore in the vicinity of the Hanford project is

complicated by the daily fluctuation in the level of the river, but the exposure rate at the river's edge during 1965 was lowest during the freshet in late June and highest during low river flow rates in the fall months. Recent measurements of the gamma-ray spectrum indicate that zinc-65 accumulated by algae growth on the substrate at the river's edge is responsible for a major portion of a fisherman's radiation exposure. Assuming that an avid fisherman spent as many as 500 hours on the river bank in the vicinity of Richland during 1965, his external exposure could have been about 15 mR.

Radioactive wastes released to ground

Liquid wastes from the chemical separations areas are routed to various facilities dependent upon their burden of radionuclides. High-level wastes (normally containing concentrations greater than 100 $\mu\text{Ci/ml}$) are stored in underground concrete tanks lined with steel. Intermediate level wastes (ordinarily containing concentrations in the range of 5×10^{-5} $\mu\text{Ci/ml}$ to 100 $\mu\text{Ci/ml}$) are sent to underground "cribs" from which they percolate into the soil. The areas selected for intermediate waste disposal and high level waste storage have soil with good ion exchange capacity and ground water depths of 50 to 100 m (165 to 330 feet). Low-level wastes (usually containing less than 10^{-5} $\mu\text{Ci/ml}$) are sent to depressions in the ground where surface ponds or "swamps" have been formed as a result of the continuous addition of the relatively large volumes of water. Wells have been drilled in and around crib and tank storage areas to detect any leaks in the tanks and to measure radionuclides that have reached the ground water. Virtually all of the radionuclides present in the ground water have been introduced with liquids sent to the cribs. The bulk of this radioactive material is ruthenium-rhodium-106. A substantial amount of tritium has also been sent to the ground with the intermediate level liquid wastes from the separations plants.

In all probability, some tritium and ruthenium-rhodium-106 originating at the chemical processing areas is now entering the Columbia River. However, the contribution of these nuclides is too small to be detectable in the

riverwater and any exposure from them is therefore negligible.

Fallout from nuclear weapons testing

In addition to the radiation dose received by residents of the Hanford environs from Hanford-originated radionuclides and from natural background radiation, a dose increment due to fallout nuclides is also received. Locally this increment is below the national average because of the low rainfall in this region (6.3 inches/year). Measurements of fallout, like measurements of natural background radiation, are necessary to place the radiation dose resulting from Hanford operations into proper perspective. The fallout nuclides of interest during 1965 were tritium, strontium-90, iodine-131, and cesium-137. Although a small transient increase in iodine-131 concentrations was observed in May and June (following the Chinese nuclear weapons test), the resulting thyroid dose was negligible.

Tritium (another fallout radionuclide), although occasionally detectable in Columbia River water, was at such low levels (near or below the detection level of 1,000 pCi/liter) that routine consumption of water obtained from the Columbia River implied an annual dose to the whole body of the "maximum" individual of less than 1 mrem. No tritium was detectable by routine methods in any other environmental media.

Concentrations of strontium-90 measured in milk produced locally are similar to concentrations found in commercial milk produced in areas that are remote from the Hanford plant. Strontium-90 found in milk from local farms averaged about 8 pCi/liter. The concentration of cesium-137 in milk analyzed at Hanford was generally near the analytical limit of 30 pCi/liter. Worldwide fallout is the principal source of strontium-90 and cesium-137 in milk.

About 10 percent of the total intake of strontium-90 by local residents during 1965 came from drinking water obtained from the Columbia River. As in the case of milk, this strontium-90 was of fallout origin.

Based on the same dietary information used in other sections of this report, the total intake of strontium-90 during 1965 was about 0.007

μCi for the "maximum" individual and 0.006 μCi for the typical Richland resident. The total intake of cesium-137 during 1965 was about 0.06 μCi for the "maximum" individual and about 0.04 μCi for the typical Richland resident. The estimated annual dose from fallout radionuclides present in the Hanford environs is given in table 6.

Table 6. Annual radiation dose from fallout radionuclides, 1965

Radionuclide	Organ	Radiation dose (mrem)	
		Maximum individual	Average Richland resident
Strontium-90	GI tract.....	1	1
	Whole body.....	1	1
	Bone.....	(2 percent MPRI)	(5 percent MPRI)
Cesium-137	GI tract.....	1	1
	Whole body.....	2	1
	Bone.....	(0.2 percent MPRI)	(0.3 percent MPRI)

Radiation exposure summary

It is not possible to determine the precise radiation dose received by every individual because of variations in the kind and quantity of food consumed, variations in sources of food supply, and many variations in personal living habits. These inherent variations among individuals require a somewhat subjective approach when estimating the probable radiation exposure in relation to various established limits. The FRC has provided two sets of guides against which doses from environmental sources may be judged; that is, one for the individuals that receive the greatest dose, and the other for the average dose received by the general population (taken as one-third of that set for individuals). For the Hanford environs, doses from the various sources described in the preceding sections have been compiled in two ways to allow comparisons with guides for both the individual and the general population. In one case a hypothetical, but plausible, individual has been assigned dietary and other habits that would result in what would seem to be the greatest rational dose. For the general population a dose has been estimated for what is called the typical Richland resident.⁴

⁴ The infeasibility of obtaining completely realistic dietary data for the typical resident leads to these assumptions: no radioactive decay takes place during the transport of drinking water to the user, there is no loss of radioactivity from food during preparation, and results of USDA dietary surveys represent the diet of the typical resident of the Hanford environs.

Some residents may receive a larger dose than calculated for the typical Richland resident but it is improbable that any would receive as much as that calculated for the "maximum" individual. Included in this intermediate group are families that subsist largely on foodstuffs produced on farms irrigated with water taken from the Columbia River downstream from the reactors.

The "maximum" individual

Attempts have been continued to identify the individuals living in the Hanford environs that receive the greatest radiation dose. Experience accumulated from the environmental surveillance program indicates such individuals are undoubtedly persons that frequently eat fish caught locally in the Columbia River, and foodstuffs grown on farms irrigated with Columbia River water. Additional data collected during 1965 continued to support the assumption that fish, consisting mainly of crappie, perch, bass, and catfish caught near Burbank (figure 2) are the most important source of radionuclides for the "maximum" individual. On the basis of an assumed con-

sumption of 200 meals/year and radiochemical analyses of such fish, the intakes of phosphorus-32 and zinc-65 for the "maximum" individual during 1965 would have amounted to 1.7 and 0.4 μCi , respectively. Whether this amount of fish was actually eaten by the individual was not confirmed. However, other persons reporting an unusually high consumption of local fish were counted in the whole body counter and were found to have far less zinc-65 deposited (by a factor of about 0.03) than predicted on the basis of their estimates of the quantities of fish eaten. As a basis for calculating the intake of radionuclides from fish, we have continued to use the maximum reported consumption of 200 fish meals per year.

The consumption rates of other foods for the hypothetical "maximum" individual are based on the maximum intakes described in various dietary surveys. It is assumed that each day this individual consumes 2 liters of water from the Pasco system, 1 liter of milk, 230 grams of beef, and nearly 200 grams of fresh leafy vegetables (in season), all produced on river irrigated farms in the Riverview District. The composite doses from these sources are illustrated in figure 2.

In the case of the thyroid gland, it is probable that the maximum exposure occurred in small children because of the relatively small thyroid mass in which the iodine-131 accumulates. The thyroid of a small child is assumed to weigh 2 grams, compared with 20 grams for the adult. On the basis of a daily intake of 1 liter of milk, 50 grams of fresh leafy vegetables produced in the Riverview District, and 0.8 liter of water from the Pasco system, the estimated annual intake of iodine-131 was about 3,400 pCi for a small child in 1965. Such an intake would result in a thyroid dose of 58 mrem or 3.9 percent of the FRC radiation protection guide for individuals.

The typical Richland resident

The vast majority of people who live in Richland, Pasco, and Kennewick obtain their food from local commercial stores (rather than directly from farms) and consume little or no fish caught from the Columbia River. The principal sources of radionuclides ingested by these people are from worldwide fallout and from

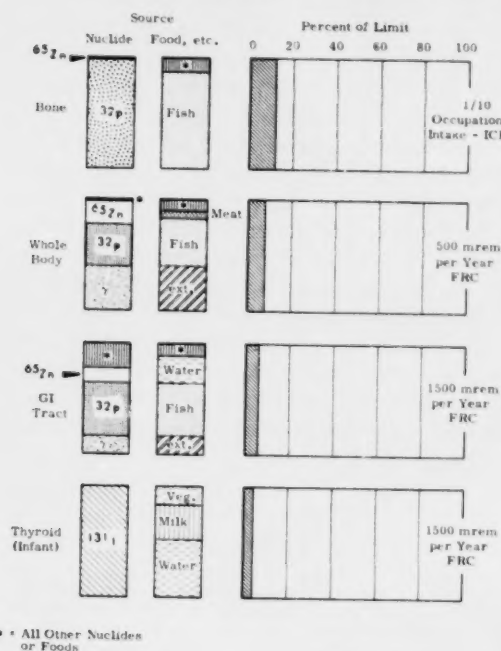


Figure 2. Estimated dose to "maximum" individual 1965

drinking water obtained from the Columbia River. It is assumed that the contribution from fallout of strontium-90 and cesium-137 is the same in all three cities. These contributions were estimated with the use of data obtained from dietary surveys made elsewhere in the United States and reported by the Federal Radiation Council (3), but adjusted on the basis of the concentration in milk sold in local stores during 1965. The estimated annual intakes of strontium-90 and cesium-137 during 1965 represented about 5 percent and 0.3 percent, respectively, of the MPRI (with bone as the critical organ).

The contribution from Hanford-created radionuclides in drinking water is substantially different for the three cities as discussed previously in the section on radionuclides in drinking water. The GI tract dose in Richland was greater than in the cities farther downriver because the short-lived nuclides are in greater abundance. As shown in figure 3, the estimated dose to typical Richland residents for 1965 was about 35 mrem, or 7 percent of the maximum permissible dose. The contribution to the GI tract dose from other sources was relatively insignificant and, conversely, the concentrations in water of bone-seeking radionuclides, such as phosphorus-32 and strontium-90, were so low that drinking water did not contribute any significant radiation dose to the bone.

For calculating a dose to the thyroid gland, the most appropriate sample of the exposed population would appear to be small children living in Richland who drank water from the municipal system (0.4 liter/day), milk (0.6 liter/day) obtained from the local stores, and fresh vegetables (25 g/day) obtained from local markets. The total intake of iodine-131 during the year from these sources would be about 1,800 pCi, or an average of about 5 pCi/day. This is in the middle of the FRC Range I and indicates a radiation dose of 30 mrem for 1965 (figure 3).

The estimated whole-body dose (figure 3) of the average Richland resident from radionuclides of Hanford origin was 5 mrem. Whole-body doses from natural background (excluded from the FRC Guide) and fallout sources in this region are estimated at about 110 mrem/year, and 2 mrem/year respectively.

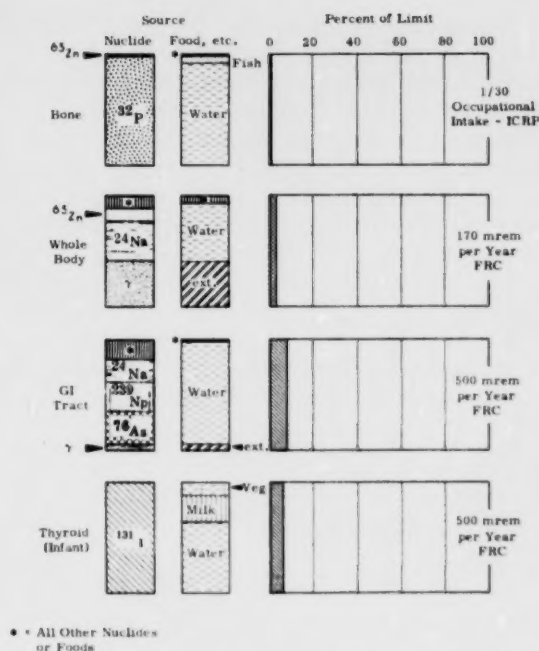


Figure 3. Estimated dose to "typical" Richland resident, 1965

Table 7 provides a summary of radiation doses estimated for individuals and population groups residing in uncontrolled areas in the Hanford environs.

Table 7. Summary of radiation doses in uncontrolled areas of the Hanford environs, 1965^a

Organ	Maximum individual			Average Richland resident		
	Annual dose (mrem)	Limit (mrem)	Percent of limit	Annual dose (mrem)	Limit (mrem)	Percent of limit
GI tract	86	1,500	6	37	500	7
Thyroid (infant)	58	1,500	4	30	500	6
Whole body	38	500	8	5	170	3
Bone	(b)	(b)	* 12	(b)	(b)	* 0.9

^a Represents individuals or population groups residing in uncontrolled areas near the Hanford plant.

^b Insufficient sampling data to provide a meaningful annual average.

* Value represents percent of maximum permissible rate of intake specified by the International Commission on Radiological Protection for individuals in the general population.

Conclusions

During 1965, the environmental surveillance program of the Hanford environs again showed that the amounts of radioactive materials present were well within nationally accepted limits at all times and that releases of radioactive wastes were well controlled.

Phosphorus-32 released to the Columbia River in reactor effluent continued to be the most significant source of radiation from the Hanford project. This phosphorus-32 is concentrated in fish that inhabit the river downstream from the reactors. Individuals who regularly eat these fish as a major part of their diet throughout the year could conceivably have taken in as much as 11 percent of the annual permissible amount of this bone seeker.

There was one unusual release of radionuclides from the Hanford plant during 1965 that warranted special assessment of the radiation dose to persons in the environs (8).

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
Third and fourth quarters 1961	October 1962
Calendar year 1962	January 1964
Calendar year 1963	January 1965
Calendar year 1964	February 1966

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2. Pinellas Peninsula Plant January-June 1966^{*}

*General Electric Company
St. Petersburg, Florida*

Pinellas Peninsula Plant, shown in figure 4, is an electronic component production facility. The plant maintains an environmental monitoring program to measure the levels of radioactive environmental contamination associated with plant effluents. These measurements serve as an index of the effectiveness of the plant's contamination control measures. Effluent radioactivity concentrations and associated atmospheric and stream dilution factors indicate that the offsite radioactivity concentrations encountered by the general population are substantially lower than the guides for continuous non-occupational exposure established by AEC and documented in the AEC Manual.

Sewer effluent monitoring

A combined sewer effluent sample is obtained daily near the perimeter of the plant's property. During the sampling period 8 of 124 samples analyzed showed concentrations of tritium greater than the minimum detectable level of 9.0×10^1 pCi/liter. The maximum concentration, 1.86×10^2 pCi/liter, was detected on February 7, 1966. Calculations based on radioactivity releases from the process waste system, and the plant's water discharges, indicate that the average tritium concentration in the combined sewer effluent for the first half of 1966 was less than 2.02 percent of the radioactivity concentration guide for continuous nonoccupational exposure.

^{*} Summarized from "Environmental Monitoring, January 1 through June 30, 1966," General Electric Company, Pinellas Peninsula Plant, St. Petersburg, Florida.

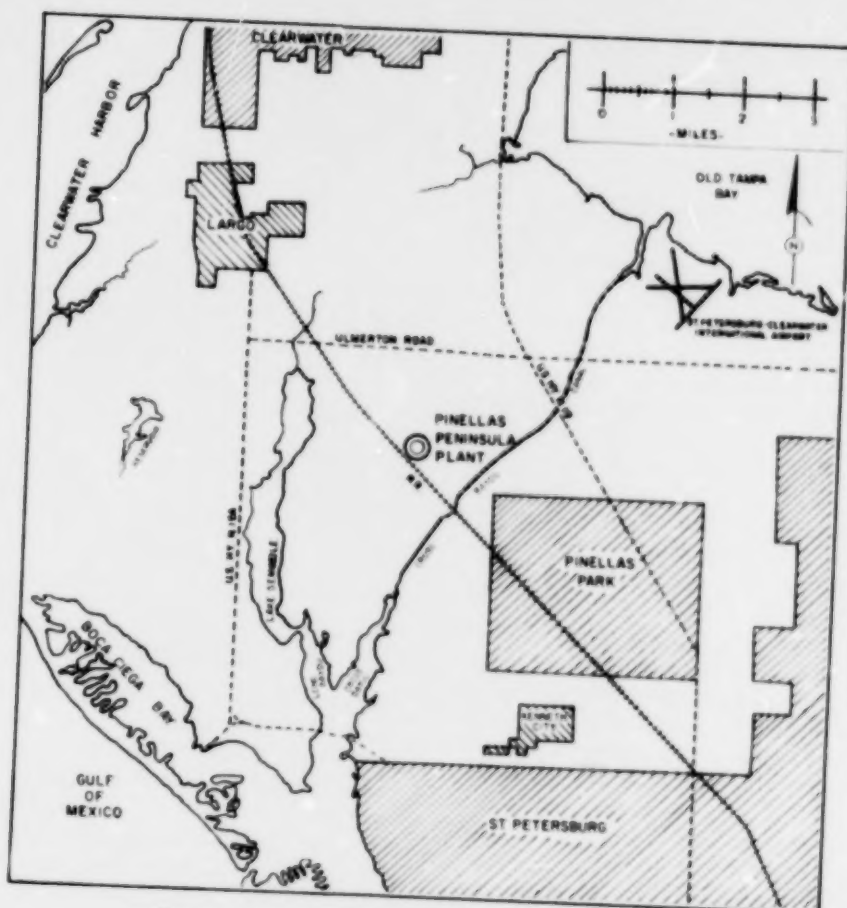


Figure 4. Location of the Pinellas Peninsula Plant

Air monitoring

Air samples are obtained periodically in areas up to 2 miles downwind from the exhaust stack. Analysis of the one sample collected during the sampling period revealed no detectable amounts of tritium gas ($9,600,000 \text{ pCi/m}^3$) or tritium oxide, above the minimum detectable levels of 9.6×10^{-4} and $5.0 \times 10^{-3} \text{ pCi/m}^3$, respectively.

Surface water sampling

Surface water samples are collected at monthly intervals at selected locations within 8 miles of the plant. The sampling areas are determined by interrelating the concentrations of radioactivity in exhaust stack effluent with meteorological data. Levels of tritium oxide in the 57 surface water samples analyzed dur-

ing the sampling period were less than the minimum detectable level of $9.0 \times 10^{-4} \text{ pCi/liter}$.

Milk sampling results

Eighteen samples of raw milk were collected from local dairy farms and analyzed by the Florida State Board of Health during the first half of 1966. No detectable concentrations greater than $9.0 \times 10^{-4} \text{ pCi/liter}$ of tritium were evident.

Recent coverage in Radiological Health Data and Reports:

Period	Issue
Calendar year 1963	September 1964
January-June 1964	February 1965
July-December 1964	August 1965
January-June 1965	February 1966
July-December 1965	August 1966

3. Savannah River Plant January-June 1967^a

*E.I. du Pont de Nemours and Company
Aiken, South Carolina*

The Savannah River Plant (SRP), built and operated for the Atomic Energy Commission by E.I. du Pont de Nemours and Company, occupies an area of 312 square miles along the Savannah River, 22 miles downstream from Augusta, Georgia. Production facilities include a fuel preparation area, four reactors, two fuel separations areas, and a heavy-water production plant. A basic goal in plant operation is total containment of radioactive waste. Although some very low-level gaseous and liquid wastes are discharged to the environment in controlled releases, dispersal is adequate to ensure environmental concentrations below recommended guides.

The DuPont environmental monitoring group has maintained a continuous monitoring program since 1951 (before plant startup) to determine the concentrations of radioactive materials in a 1,200 square mile area outside the plant. Included in this area are parts of Aiken, Barnwell, and Allendale counties in South Carolina, and Richmond, Burke, and Screven counties in Georgia. This surveillance determines the magnitude and origin of any radioactivity above natural levels. Measured concentrations of radionuclides in air, water, and milk are compared with the maximum permissible concentrations (MPC) recommended by the International Commission on Radiological Protection (ICRP), or the daily intake guides recommended by the Federal Radiation Council (FRC).

Sensitive instruments, which can detect traces of radioactive material far below concentrations of hazard significance, are used to determine radioactivity in the environs. Plant-released radioactivity cannot be readily distinguished from weapons-tests fallout, and both are included in the reported concentrations. Maximum and minimum values given are for individual samples collected during the report period.

^a Summarized from "Effect of the Savannah River Plant on Environmental Radioactivity, Semiannual Report, January-June 1966," DPST-66-30-2.



Figure 5. Environmental sampling locations, Savannah River Plant

Atmospheric monitoring

Concentrations of radioactive materials in the atmosphere were measured by weekly analyses of air filters collected at five monitoring stations near the plant perimeter and 10 stations around a circle of about 25 miles radius from the center of the plant (figure 5). Deposition rates of radioactive material at each station were also determined by monthly analyses of rain-water ion exchange columns (fallout collectors). The monitoring stations are spaced so that a significant release of airborne activity by SRP would be detected regardless of the prevailing wind. All stations operate continuously. Four additional air monitoring stations at Savannah and Macon, Georgia, and at Columbia and Greenville, South Carolina, are so distant from SRP that the effect of SRP operations is negligible; they are reference points for determining background activity levels (figure 6). This system permits comprehensive surveillance of atmospheric radioactivity and also makes it possible to differentiate between test fallout and SRP releases.

The small amount of filterable beta radioactivity released to the atmosphere, primarily from the fuel separations areas, was obscured by fallout from nuclear weapons tests. The

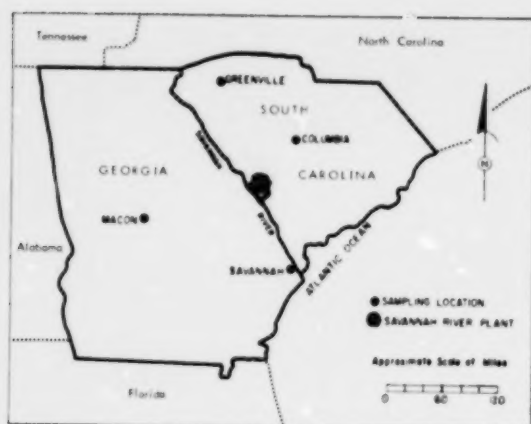


Figure 6. Distant air monitoring stations Savannah River Plant

influence of the weapons tests which resumed in September 1961 is shown in figure 7. The rises in early 1964, 1965, and 1966 were the result of the anticipated spring increases in the mixing of stratospheric debris into the troposphere. The Chinese nuclear tests conducted in May 1965 and May 1966 contributed to the airborne radioactivity during June of both years.

Radioactivity in air, determined from filter analyses, is shown in table 8. The January to June 1966 concentrations of filterable beta radioactivity (0.12 pCi/m^3) and alpha radioactivity (0.0008 pCi/m^3) in air were 0.1 and 2.0 percent of the respective MPC's. Tritium oxide concentrations in air, at the plant perimeter and at the 25-mile stations, did not exceed 1.1 percent of the MPC. Iodine-131 concentra-

tions in routine air samples were less than 0.02 pCi/m^3 , the lower detection limit, throughout the period.

Deposition of fallout during the first half of 1966 totaled 96.1 nCi/m^2 at plant perimeter locations and 69.5 nCi/m^2 at 25-mile-radius locations; comparable values for the last half of 1965 were 3.9 and 3.5 nCi/m^2 . Fallout from the Chinese weapons test (primarily short-lived barium-lanthanum-140) accounted for the large increase. Beryllium-7, a radionuclide continuously being produced in nature by cosmic interactions in the upper atmosphere, was a measurable component in environmental radioactivity; the average deposition, 10.8 nCi/m^2 , was about the same as during July through December 1965. Deposition at each sampling location is presented in table 9.

Vegetation

Radioactive contamination of growing plants may result from deposition on foliar surfaces or absorption of radioactive materials from the soil.

Grass samples were collected at seven locations along the plant perimeter and at nine other locations along a 25-mile-radius route. (These are not designated on figure 5.) Samples from each quadrant of the plant and of the surrounding area were composited for monthly analysis. Radionuclides in grass samples were from fallout. Alpha-particle emitters averaged 0.2 pCi/g at the plant perimeter and 25-mile-radius locations as compared to 0.1 pCi/g during the last half of 1965; gamma-

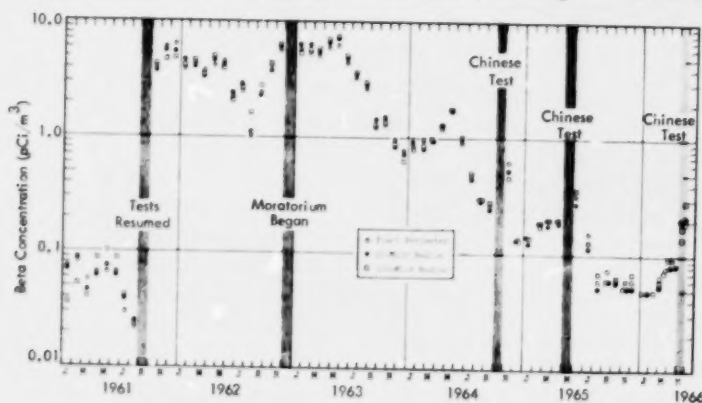


Figure 7. Influence of weapons tests

Table 8. Radioactivity in air, Savannah River Plant, January-June 1966

Filter analysis	Average concentrations (pCi/m ³)																
	Plant perimeter locations						25-mile-radius locations										
	A	B	C	D	E	Average	Aiken Air-port	Aiken State Park	Alendale	Barnwell	Bushfield	Langley	Sardis	Waynesboro	Williston	Highway 301	Average
Alpha-particle emitters * (multiply by 10 ⁻³)																	
Maximum	2.2	2.2	2.3	1.9	2.0		2.7	2.2	1.6	3.0	1.5	2.2	1.4	1.8	2.6	2.2	
Minimum	0.3	0.6	0.3	0.3	<0.3		<0.3	<0.3	0.3	<0.3	0.3	0.5	0.5	0.4	0.4	0.3	
Average	0.8	1.0	0.9	0.8	0.7	0.8	0.9	0.7	0.7	0.8	0.8	0.9	0.8	0.9	0.9	0.7	0.8
Nonvolatile beta-particle emitters *																	
Maximum	0.30	0.26	0.27	0.28	0.27		0.35	0.31	0.49	0.34	0.29	0.36	0.34	0.32	0.25	0.30	
Minimum	0.04	0.04	0.04	0.04	0.04		0.03	0.04	0.05	0.04	0.03	0.04	0.04	0.05	0.02	0.02	
Average	0.12	0.12	0.11	0.12	0.12	0.12	0.14	0.12	0.14	0.12	0.11	0.12	0.11	0.12	0.12	0.11	0.12
Specific radionuclides (averages)																	
Cesium-137	Composite sample						Composite sample										
Cesium-141, 144	0.01						0.01										
Ruthenium-103, 106	0.03						0.02										
Zirconium-niobium-95	0.01						0.01										
Manganese-54	<0.003						<0.003										
Beryllium-7	<0.003						<0.003										
	0.03						0.04										

* Sensitivity of analysis— 3.0×10^{-4} pCi/m³.
 * Sensitivity of analysis—0.006 pCi/m³.

Table 9. Total fallout deposited, Savannah River Plant, January-June 1966

Radionuclide	Fallout deposition (nCi/m ²)																
	Plant perimeter locations						25-mile-radius locations										
	A	B	C	D	E	Average	Aiken Air-port	Aiken State Park	Alendale	Barnwell	Bushfield	Langley	Sardis	Waynesboro	Williston	Highway 301	Average
Alpha particles *	2.39	2.97	5.79	2.13	2.43	3.36	1.62	2.47	1.74	2.82	2.59	4.32	0.93	2.08	2.43	2.16	2.32
Beryllium-7	11.04	14.20	12.39	12.55	13.43	12.74	8.11	4.21	8.45	8.96	12.24	9.11	4.97	9.03	8.07	11.97	8.49
Manganese-54	0.15	0.15	0.19	0.12	0.15	0.15	0.08	0.15	0.08	0.12	0.19	0.15	0.15	0.15	0.15	0.08	0.12
Strontium-90	3.13	4.17	9.57	4.55	7.84	5.87	2.35	2.59	7.80	7.37	5.21	2.97	3.24	4.48	3.67	2.39	4.21
Strontium-90	0.97	1.20	1.35	1.24	1.78	1.31	0.77	1.24	1.39	1.62	1.54	1.24	0.97	1.47	1.20	2.16	1.35
Zirconium-niobium-95	5.17	1.93	10.96	1.94	9.53	6.29	2.97	3.24	5.79	4.90	2.93	8.57	3.63	2.86	1.43	3.90	4.01
Ruthenium-103, 106	9.84	8.11	8.92	9.59	16.21	10.34	6.14	8.30	15.25	15.52	7.80	8.96	8.69	13.05	3.59	12.89	10.27
Iodine-131	13.36	11.73	11.54	9.89	19.65	13.43	6.76	11.16	22.62	16.75	9.84	10.42	12.81	15.48	4.94	9.34	12.00
Cesium-137	1.97	1.47	1.47	1.53	1.85	1.66	1.39	1.70	2.08	2.08	2.08	1.66	1.27	1.74	1.39	1.81	1.74
Barium-lanthanum-140	32.73	45.93	49.56	41.07	81.06	50.06	14.01	17.41	48.33	42.46	27.14	25.78	18.57	30.15	14.09	56.78	29.49
Cesium-141, 144	6.18	4.63	8.69	5.25	10.42	7.03	4.25	4.79	9.92	8.53	6.48	6.95	5.17	6.99	2.39	6.33	6.18

* Multiply by 10⁻¹.

ray activities averaged 51 and 38 pCi/g, respectively, as compared to 22 and 18 pCi/g for the last half of 1965. Beryllium-7 comprised about 40 percent of the average gamma radioactivity found on vegetation during the period January through June 1966.

Milk

Milk was sampled at four dairies within a 25-mile radius of SRP, as shown in figure 5. Some samples were collected weekly and some biweekly. These samples were analyzed for

tritium, radiocesium, and radioiodine. Strontium-90 determinations were made quarterly. Milk produced in the area and sold by major distributors was also analyzed for these radionuclides. Results from analyzing milk for radioactivity during January through June 1966 are in table 10. Average concentrations of three radionuclides in milk (47 pCi/liter for cesium-137, 26 pCi/liter for strontium-90, and 7 pCi/liter for iodine-131) were consistent with values reported by the U.S. Public Health Service for most sections of the United States

Table 10. Radioactivity in milk from local dairies, Savannah River Plant, January-June 1966

Location of local dairies	Concentration (pCi/liter)										
	Tritium ^a			Strontium-90 ^{b, c}		Iodine-131 ^d			Cesium-137 ^e		
	Maximum	Minimum	Average	March 1966	June 1966	Maximum	Minimum	Average	Maximum	Minimum	Average
Aiken.....	3,000	<3,000	<3,000	23	26	26	<5	6	90	<30	34
Allendale.....	8,500	<3,000	<3,000	22	30	56	<5	11	118	<30	56
North Augusta.....	19,000	<3,000	<3,000	25	26	44	<5	6	61	<30	46
Waynesboro.....	9,000	<3,000	<3,000	NS	24	27	<5	6	51	<30	37
Major distributors.....	7,000	<3,000	<3,000	28	26	31	<5	7	57	<30	43

^a Sensitivity of analysis—3,000 rCi/liter.

^b Sensitivity of analysis—1.0 pCi/liter.

^c Strontium-90 determinations were made quarterly.

^d Sensitivity of analysis—5.0 pCi/liter.

^e Sensitivity of analysis—30 pCi/liter.

^f Milk produced in local dairies, but sold by major distributors.

NS, no sample collected.

during the first half of 1966. Tritium in local milk, when present, is assumed to be associated with plant operations. The average tritium level was less than the sensitivity of the analysis, which allows detection of concentrations of 3.0×10^{-3} pCi/liter (1 percent of the MPC for water).

Food

Radioanalysis of farm produce collected during 1965 was completed during the first half of 1966. More than 40 samples representing 4 food categories (fruit, grain, leafy vegetables, and poultry) were collected during the harvest season at 14 localities in the 6 counties surrounding SRP (not shown on figure 5). With the exception of grains, all foods were prepared for analysis in a manner similar to that used to prepare them for eating. Peelings, seeds, and other nonedible parts were removed. Wheat, containing the whole grains only, and oats, containing both grains and husks, were processed unwashed. Gamma-ray spectrometry was used to analyze samples for cerium-144, ruthenium-103, ruthenium-106, cesium-137, manganese-54, and zirconium-niobium-95. Radiostrontium and alpha radioactivity were determined by radiochemical analysis. SRP contributions to the levels of radioactivity in foods were so low in 1965 as to be indistinguishable from weapons-test fallout.

Algae and fish in Savannah River

Weekly samples of fish, predominantly bream, and indigenous algae, primarily green (*Vaucheria*) and blue-green (*Phormidium*), were collected upstream from, adjacent to, and downstream from the Savannah River Plant. Determination of radionuclides in algae is important because algae concentrate certain radionuclides and also because of the role of algae in the food chain of aquatic organisms. Concentrations of beta-particle emitters in algae and fish adjacent to and downstream from SRP indicate some minor contribution by SRP. Although measurably higher than similar material collected at the control station 3 miles upstream from SRP, the slight increase is of no biological significance.

Specific radionuclide analyses were made on algae and fish collected from the Savannah River. Radiocesium and radiostrontium were found consistently in river algae; whereas cerium-141, cerium-144, chromium-51, zirconium-niobium-95, manganese-54, zinc-65, and cobalt-60 were detected less frequently. Also, radiostrontium (maximum, 45 pCi/g, wet weight) was detected in bone tissue of river fish, and radiocesium (maximum, 26 pCi/g, wet weight) was detected in the flesh tissue. Radiozinc and phosphorus-32 were detected less frequently in these tissues. The maximum concentrations of phosphorus-32 detected in bone and

flesh tissues of river fish were 313 pCi/g, and 30 pCi/g, respectively.

Water monitoring

The plant site is drained by five streams which flow several miles through the reservation before reaching the river (figure 8). In January 1965, the Beaufort-Jasper Water Authority began operation of a new treatment facility to furnish drinking water, partially supplied from the Savannah River, to most of Beaufort County, S.C. Water is supplied through a new canal from the river at a location about 90 miles below the SRP. The city of Savannah also supplements its domestic well water supply with river water during periods of peak demand.

Communities near SRP get domestic water from deep wells or surface streams. Public water supplies from 14 surrounding towns were collected and analyzed monthly. There was no evidence that SRP contributed radioactivity to drinking water supplies; concentrations of alpha radioactivity (1.3 pCi/liter) and beta radioactivity (6 pCi/liter) were essentially the same as those observed before plant startup.

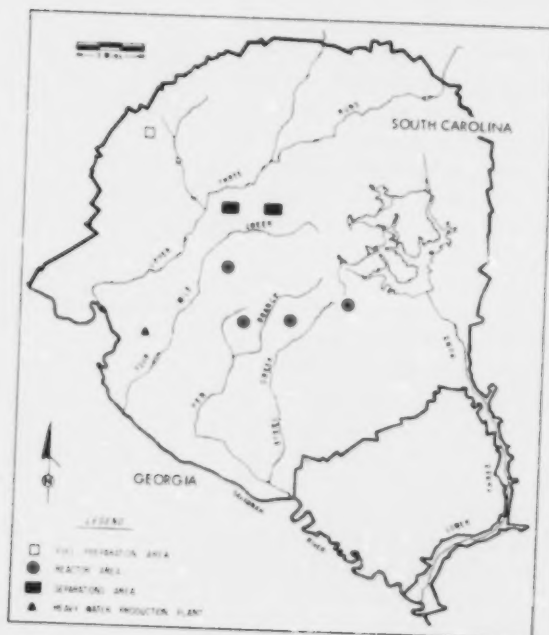


Figure 8. SRP production areas and effluent streams

River water, analyzed weekly, was sampled continuously at four locations, as shown in figure 5. Average concentrations of specific radionuclides found in river water during January-June 1966 are shown in table 11.

Table 11. Average concentration of radionuclides in Savannah River water, Savannah River Plant January-June 1966

Radionuclide	Concentration (pCi/liter)			
	Sensitivity of analysis	Control (3 miles upstream from plant)	Highway 301 (10 miles downstream from plant)	Percent MPC at Highway 301
Tritium-3	600	1,100	11,000	3.7
Chromium-51	4.3	<4.3	28.9	0.004
Manganese-54	0.4	<0.4	<0.4	<0.001
Cobalt-60	1.4	<1.4	<1.4	<0.01
Zinc-65	1.1	<1.1	<1.1	<0.01
Strontium-89	0.3	<0.3	0.8	—
Strontium-90	0.01	1.1	1.8	—
Zirconium-niobium-95	0.5	<0.5	0.6	0.003
Ruthenium-103, 106	3.2	<3.2	<3.2	<0.10
Iodine-131	0.5	<0.5	0.3	—
Cesium-134, 137	0.6	<0.6	2.1	0.10
Barium	—	—	—	—
Lanthanum-140	1.6	<1.6	1.8	0.03
Cerium-141, 144	2.5	<2.5	2.9	0.10
Neptunium-239	0.9	1.1	2.6	0.01

Cesium-137, strontium-89, strontium-90, chromium-51, tritium, and trace amounts of cerium-141, zirconium-niobium-95, and iodine-131, released mainly from reactor areas, were the radionuclides of SRP origin detectable in river water at the downstream location. Average concentrations of all radionuclides found in river water during January through June 1966 were only small fractions of the permissible concentrations. The tritium concentrations in finished water collected from the Beaufort-Jasper Water Plant averaged 5,600 pCi/liter (1.9 percent MPC) during the 6-month report period.

Tritium, a beta-ray emitter and the most abundant radionuclide released to the river, is produced by neutron irradiation of heavy-water moderator in the reactors. Chromium-51, the second most abundant radionuclide released to the river, is produced by neutron irradiation of stable chromium (a component of the stainless steel used in reactor parts). Tritium and chromium-51 are among the least dangerous of all radionuclides because neither concentrates in body tissues. The tritium and

chromium-51 concentrations in river water averaged 3.7 and 0.004 percent MPC, respectively.

Environmental gamma radiation levels

Monthly measurements of environmental gamma radiation were made with thermoluminescent dosimeters. January through June 1966 data (shown in table 12) are considered more representative than previous data obtained by monthly spot readings using portable Geiger-Mueller survey instruments.

Summary

The quantity of radioactive waste released by the Savannah River Plant to its environs during the period January through June 1966 was, for the most part, too small to be distinguished from natural background radiation or was obscured by worldwide fallout from nuclear weapons testing. Fallout from the Chinese nuclear test on May 9, 1966, was detected at SRP.

Beta radioactivity in air, which showed no relationship with plant operations, was about one-half that for the same period of 1965. Radioactive materials in fish flesh continued to be far below levels considered significant from a health standpoint. The average concentration of radionuclides in river water did not exceed 3.7 percent of the maximum permissible concentrations.

Recent coverage in Radiological Health Data and Reports:

Period	Issue
July-December 1961	September 1962
Calendar year 1962	August 1963
Calendar year 1963	August 1964
January-June 1964	February 1965
July-December 1964	August 1965
January-June 1965	February 1966
July-December 1965	August 1966

Table 12. Environmental gamma radiation, Savannah River Plant, January-June 1966

	Exposure rate (mR/day)															
	Plant perimeter locations						25-mile-radius locations									
	A	B	C	D	E	Average	Aiken Airport	Aiken State Park	Alledale	Burnwell	Bushfield	Langley	Sardis	Waynesboro	Williston	Highway 301
Maximum.....	0.30	0.36	0.35	0.31	0.41		0.32	0.22	0.24	0.26	0.30	0.26	0.31	0.25	0.32	0.27
Minimum.....	0.25	0.26	0.26	0.24	0.25		0.21	0.19	0.21	0.20	0.23	0.20	0.23	0.17	0.21	0.12
Average.....	0.27	0.29	0.30	0.27	0.29	0.28	0.25	0.20	0.22	0.23	0.27	0.23	0.26	0.22	0.25	0.22
																0.24

1. Shippingport Atomic Power Station January-June 1966:

*Duquesne Light Company
Shippingport, Pennsylvania*

The Shippingport Atomic Power Station is operated for the Atomic Energy Commission by the Duquesne Light Company. The plant site is located near Shippingport, Pennsylvania, along the Ohio River about 25 miles northwest of Pittsburgh (figure 9).

¹ Summarized from "Environmental Radioactivity at the Shippingport Atomic Power Station for the First Half of 1966," PNRO-SMD-139.

The pressurized water reactor with Core 1 ("seed and blanket" design) achieved full power on December 23, 1957, and has operated continuously except for shutdowns which were necessary for maintenance and "seed" refueling. In February 1964, the reactor was shutdown for the replacement of Core 1 with Core 2, the decontamination of the primary system, and the commencement of other associated reactor plant modifications. The reactor remained shut down until April 1965, at which time operations were resumed.

An environmental monitoring program was started 2 years before plant startup to determine the background levels of radioactivity in

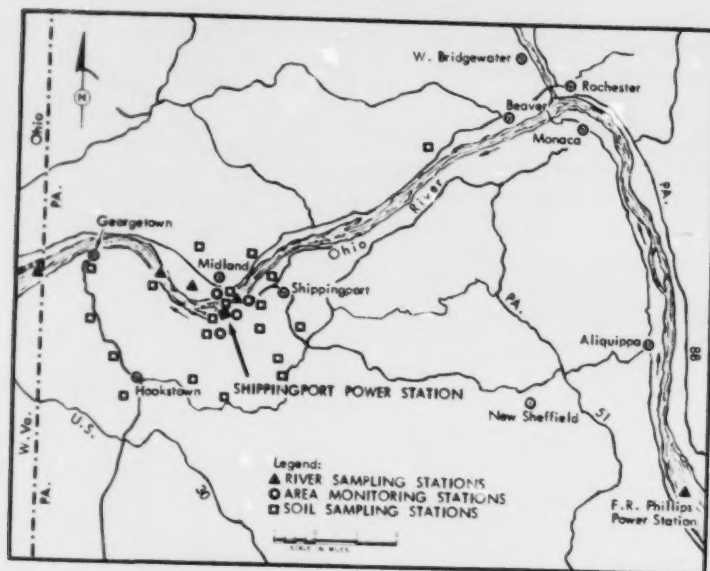


Figure 9. Shippingport power station sampling locations

the environment. This program was continued after plant startup to ensure that radioactive wastes discharged from normal plant operations do not cause significant changes in these levels in the plant environment.

In January 1966, environmental monitoring program was revised in the following manner:

1. fallout and precipitation sampling at three locations surrounding the station was reduced to one sample taken at one onsite location,
2. the continuously recording beta-gamma radiation monitors and the continuously recording airborne particulate monitors for radioactivity situated at three locations surrounding the station were eliminated. For monitoring significant airborne releases of radioactivity in case of an accident, 12 film badges were located surrounding the station and changed on a quarterly basis,
3. the sampling of river sediment upstream and downstream from the station's outfall was commenced on a quarterly basis.

Liquid radioactive waste disposal

The concentration limits for the discharge of radioactive wastes at Shippingport are based

on a knowledge of the radionuclide mixture making up the waste and on the radiation protection standards of Title 10, Code of Federal Regulations, Part 20, AEC Manual, Chapter 0524 and Chapter 4, Article 433 of the Rules and Regulations, Commonwealth of Pennsylvania Department of Health. The discharge of tritium, which is less hazardous than fission and activated corrosion products, is controlled separately using the prescribed AEC concentration guides in each case. The liquid effluent from the plant radioactive waste disposal system is carefully monitored before, during, and after release to the Ohio River to ensure that the concentration limits recommended by the above regulations are not exceeded.

The liquid radioactive wastes discharged during the first half of 1966 are summarized in table 13 and 14. The monthly average concentrations of gross radioactivities shown in table 13 include normal background radioactivity and are calculated after total radioactive waste discharges are diluted in the condenser cooling water effluent channel. The maximum total discharge in 1 day during the first half of 1966 was 1.27 millicuries.

Table 13. Total radioactive waste, exclusive of tritium, discharged into the Ohio River, Shippingport Atomic Power Station, January-June 1966

Period	Total radioactivity (mCi)	Average radioactivity (mCi/day)	Average radioactivity in effluent channel (pCi/liter)
January.....	5.77	0.186	5.82
February.....	6.09	0.218	5.14
March.....	4.41	0.142	2.94
April.....	3.77	0.126	2.78
May.....	4.39	0.142	1.88
June.....	2.81	0.094	1.05
Summary.....	27.24	0.150	2.71

Table 14 is a summary of the tritium that was discharged into the Ohio River, the monthly average tritium radioactivity in the hold-up tanks prior to discharge, and monthly average concentration of the radioactive waste in the effluent channel after dilution with the condenser cooling water. The maximum quantity of tritium discharged in 1 day during the first half of 1966 was 297 millicuries.

Table 14. Tritium released to Ohio River, Shippingport Atomic Power Station, January-June 1966

Period	Total tritium activity (mCi)	Average tritium activity (mCi/day)	Average tritium activity in hold-up tanks (10^3 nCi/liter)	Average tritium activity in effluent channel (nCi/liter)
January.....	405	13.1	2.81	0.65
February.....	608	21.7	2.87	0.85
March.....	1,392	45.0	7.28	2.11
April.....	1,517	50.5	8.18	1.91
May.....	2,253	72.5	10.13	1.60
June.....	2,764	92.0	12.52	1.72
Summary.....	8,939	49.4	7.62	1.54

Automatic samplers are installed at the station's river water influent and effluent to collect water samples continuously for comparative purposes. Since the effluent sampler was inoperative from January through May 1966 daily grab samples were collected. Weekly composites of the daily grab samples and continuous samples were analyzed for gross beta and gross alpha radioactivities in the suspended and dissolved solids. The potassium-40 radioactivity in the total solids of these samples was also measured. No significant difference was observed between the average alpha, beta, and potassium-40 radioactivity in the influent and effluent samples. The results of these analyses are shown in table 15.

Table 15. Gross radioactivity in the Ohio River, Shippingport Atomic Power Station, January-June 1966

Type of radioactive material	Average radioactivity of influent samples (pCi/liter)			Average radioactivity of effluent samples (pCi/liter)		
	Maximum	Minimum	Average	Maximum	Minimum	Average
Alpha radioactivity						
Suspended solids.....	28.10	0.01	1.59	4.66	0.02	0.44
Dissolved solids.....	6.56	0.14	0.65	4.09	0.23	0.54
Total solids.....	29.23	0.30	2.24	5.10	0.30	0.97
Beta radioactivity						
Suspended solids.....	58.95	0.19	8.30	19.20	0.29	5.71
Dissolved solids.....	16.57	1.59	5.91	12.06	0.93	6.22
Total solids.....	45.27	4.41	14.20	25.26	2.00	11.93
Potassium-40						
Total solids.....	6.40	2.70	4.59	6.60	2.70	4.59

Atmospheric release of radioactive materials

During the first half of 1966, a total of 30.4 mCi of xenon-133 was released at Shippingport at concentrations less than the MPC of 3×10^5 pCi/m³. The incinerator, which is used for burning combustible contaminated waste, was not operated.

Environmental monitoring

Twelve beta-gamma-ray-sensitive film badges were posted around the station boundary to determine external radiation exposure from environmental radiation and from station operations. However, due to the effect of temperature and humidity, reliable results were not obtained from the film badges during this report period. For this reason, no data on radiation levels are presented.

River sediment samples were collected from the Ohio River once each calendar quarter upstream and downstream from the station's liquid waste outfall. These samples were gamma-counted and quantified assuming all detected radioactivity to be due to cobalt-60, which is the major constituent of radioactive contamination at the station. Gross radioactivity in the sediment for the first and second calendar quarters were, respectively, 11.11 and 9.07 pCi/g upstream and 7.29 and 9.87 pCi/g downstream from the outfall. These results indicate that there was no appreciable increase of radioactivity in the river sediment as the result of the station's discharges of radioactive contaminated liquid wastes.

Radioactive fallout was collected in a pot at one onsite location and analyzed weekly for alpha and beta radioactivity. The average first quarter, second quarter and first half of 1966 results are depicted in table 16.

Table 16. Radioactivity in fallout, Shippingport Atomic Power Station, January-June 1966

Period	Fallout deposition rate (nCi/m ² · month)	
	Alpha radioactivity	Beta radioactivity
January-March	0.22	4.79
April-June	0.60	37.27
January-June	0.41	21.03

Summary

During the first half of 1966, measurements of radioactivity were made in the Ohio River and in the vicinity of the Shippingport Atomic Power Station. The results of these measurements indicate that the radioactive material released by the power station into the Ohio River did not result in a significant change in the naturally occurring radioactivity in the environment.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July 1962-June 1963	March 1964
July-December 1963	November 1964
Calendar year 1964	August 1965
January-June 1965	February 1966
July-December 1965	July 1966

Section V. Technical Notes

REPORTED NUCLEAR DETONATIONS, JANUARY 1967

During January 1967, two U.S. nuclear tests at the Nevada Test Site were announced by the Atomic Energy Commission.

On January 19, and January 20, 1967, underground nuclear tests were conducted. Both tests were in the low-intermediate yield range (equivalent force of 20 to 200 kilotons of TNT).

SYNOPSIS

Synopses of reports, incorporating a list of key words, are furnished below in reference-card format for the convenience of readers who may wish to clip them for their files.

RADIONUCLIDE LEVELS IN MILK, TOTAL DIET, AND HUMAN BONE COMPARED TO FEDERAL RADIATION COUNCIL ESTIMATES, 1965, AND 1966 ESTIMATES. *U.S. Public Health Service, National Center for Radiological Health. Radiological Health Data and Reports, Vol. 8, February 1967, pp.*

Estimates of the levels of fallout radionuclides in environmental media and in human bone expected from 1963 through 1965 have been made by the Federal Radiation Council. The 1965 observed values are compared with the FRC predictions and 1966 levels are estimated using the approach proposed by the Federal Radiation Council. The observed radionuclide levels are in agreement with the prediction made by the Radiation Council. The observed levels and the predicted levels of radioactivity in food over the next several years are too small to justify protective action to limit the dietary intake of radionuclides.

KEY WORDS: bone, calcium, cesium-137, diet, iodine-131, milk, Pasteurized Milk Network, protection guides, radiation, strontium-89, strontium-90.

STRONTIUM-90 DIETARY INTAKE ESTIMATES BASED ON FRACTIONAL INTAKES DUE TO MILK. *R. O. Grundy. Radiological Health Data and Reports, Vol. 8, February 1967, pp. 73-77.*

Strontium-90 dietary intake estimates were made for the Institutional Total Diet Sampling Network based upon Pasteurized Milk Network concentrations. Approaches based upon milk-to-total-diet ratios of strontium-90 and strontium units were considered. The approach based upon strontium units yielded the best estimates of ITDSN monthly average and maximum strontium-90 intakes on a Network basis for the population groups involved.

KEY WORDS: Calcium, diet, Institutional Total Diet Sampling Network, intakes, milk, Pasteurized Milk Network, strontium-90, strontium unit.

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 8, Number 3 March 1967

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the National Center for Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators. These are subject to review by a Board of Editorial Advisors with representatives from the following Federal agencies:

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RADIATION HAZARDS IN URANIUM MINES

D. A. Holaday¹

A review of health studies of U.S. uranium miners is presented. The primary radiation hazard in uranium mines is alpha radiation which is delivered to the lungs by radon-222 and its short-lived daughters. The appearance of lung cancer among uranium miners has been studied and was found to be excessive. The cell-type distribution of these cancers of uranium miners is different from that of the general population. Calculation of radiation dosage to the lungs of miners is difficult.

General dilution ventilation is the primary method of controlling the radiation hazard, but it has limitations. Radiation exposure of uranium miners has gradually been reduced.

Sixteen years have elapsed since a study of radiation hazards in uranium mines was undertaken jointly by the U.S. Public Health Service and the State health departments of Colorado, Arizona, New Mexico, and Utah. Many different individuals and groups have contributed their efforts to this project, and a great deal of information has been accumulated which demonstrates that uranium miners have had the most significant exposures to radiation of any industrial group in this country.

In 1950 about 500 men were engaged in mining uranium ores in the Colorado Plateau, mostly in small underground workings, with an average production of about 1 ton per man-day. The employment peak was reached in 1960 when about 5,800 underground miners were employed. Approximately 2,800 miners are now working and are producing 3 tons of ore per man-day. The Public Health Service Occupational Health Field Station now has on file environmental data on over 1,200 different mining operations, but an unknown addi-

tional number of operations were never surveyed. During the third quarter of 1965, environmental samples were obtained in 229 mines, which is somewhat greater than the number of mines working at any one time. A number of mines opened or closed during this period, but the number of active mines remained fairly constant throughout the year. This pattern of operation, which has prevailed during the life of the industry, has complicated attempts to control the hazards to which the miners are exposed, and to maintain occupational and environmental records.

Since 1950, many thousands of men have been exposed to the radiation hazard in uranium mines created by radon-222 and its short-lived daughters. While the environmental data obtained in the early years of the study are indeed sparse, consisting of one survey per year at best in most of the mines, it is possible to make estimates of the atmospheric concentrations of radon-222 and its daughters to which the men were exposed. Table 1 presents two such estimates.

These numbers can be meaningful when compared with levels that were found in several studies of European mines. Since only radon-222

¹ Mr. Holaday is chief of the Occupational Health Field Station, National Center for Urban and Industrial Health, Public Health Service, Salt Lake City, Utah 84113.

Table 1. Estimates of exposures to various environmental levels of radon-222 and its daughters in uranium mines, 1952 and 1957

1952		1957	
Multiple of working level *	Percent of men affected *	Multiple of working level *	Percent of men affected *
<0.5	15.8	<0.5	8.2
0.5-2.5	16.1	0.5-1.9	24.3
2.5-10.0	23.4	2.0-9.9	44.2
>10.0	44.7	>10.0	23.3

* 1.3×10^6 MeV of potential alpha-particle energy per liter of air
 * Total of 733 men
 * Total of 1,890 men

concentrations were measured in the European mines, it is necessary to make assumptions concerning the equilibrium ratios between radon and its daughters that may have prevailed in the mines, to estimate the "working levels" of radon daughters that existed. Using these assumptions, it appears that the European miners were exposed to radon-daughter concentrations of from 10 to 180 times the working level. (One working level is equivalent to 100 pCi of radon-222 at equilibrium with its daughters per liter of air.) A large proportion of American uranium miners worked in situations similar to those in Europe.

The effects of these exposures as measured by the incidence of lung cancer have been analyzed in detail in a report of a mortality study of 3,415 miners, by Wagoner *et al.* (1). By December 31, 1963, 249 deaths had occurred in this group, of which 30 were caused by lung cancer. The data showed that lung cancer was related to the total cumulative exposure to radon-222 and its daughters and that the age-standardized incidence rate increased from 3.10 cases per year per 10,000 men in the lowest cumulative-exposure group (<120 WLM)² to 116.12 cases per year per 10,000 men in the highest cumulative-exposure group (>3,720 WLM). An etiological association appears between the concentration of radon-222 and its daughters, length of exposure, and lung cancer.

Conclusions concerning the degree of increased risk of lung cancer in uranium miners can only be speculative at present. For most of the study group, it was found that the time

from first exposure to the appearance of lung cancer has been shorter than the median time for development of lung cancer (in uranium miners this appears to be about 17 years). We now know that at least 50 cases of lung cancer have occurred in this group of miners, and it is certain that additional cases will develop. The situation is also complicated by the fact that the proportion of miners dying in industrial accidents is much larger than it is in the general industrial population. However, it can be stated that the number of deaths from lung cancer in the members of the study group has greatly exceeded the expected number and that the incidence has increased with continuing exposure to radon-222 and its daughters.

A study of cancer-cell types reported by Saccomanno and Archer showed some interesting differences between uranium miners and a matched age-smoking-history control group of nonminers (2).³ These findings are summarized in table 2.

Table 2. Comparison of cancer-cell types in uranium miners and a matched control group of nonminers

Cancer-cell type	Age-smoking matched control group (percent)	1 to 360 WLM * (percent)	361 to 1,200 WLM * (percent)	>1,200 WLM * (percent)
Epidermoid	62.1	61.5	42.1	13.8
Oat cell, round cell, polygonal cell	17.6	38.5	47.3	78.9
Large cell (undifferentiated)	5.9	0	0	0
Adenocarcinoma, combined adeno-epidermoid, alveolar cell	13.7	0	10.6	5.3
Total cases	51	13	19	19

* WLM, working level months, represents cumulative radiation exposure in uranium mines.

The data showed that the fraction of oat-cell, round cell, and polygonal cell cancers increased with continuing exposure to radon daughters. The clinical record of cancer cases in uranium miners also showed that the disease is highly malignant and progresses rapidly. The average time from diagnosis to death is 2.5 months.

The radioactive portion of the aerosols to which uranium miners are exposed is formed by the decay of radon-222 and its daughters in the mine atmosphere. Radon-222 and its

³ Each uranium miner was matched with a non-uranium miner. Pairs were matched as closely as possible for age and smoking history.

² WLM, working level months, represents cumulative radiation exposure in uranium mines.

daughter products thus exist initially as individual atoms which diffuse rapidly and become attached to the first surface they encounter. Since most dust particles in mine air are less than 5 microns in diameter, essentially all of the radon-222 and its daughters are either attached to respirable particulates or exist as free atoms. Studies in mines have shown that this condition does indeed exist, and that the fraction of activity present as free atoms varies widely, depending on mine conditions (3). It is difficult to estimate radiation doses to the lung because the fraction deposited and the sites of deposition of the radon-222 and its daughters are greatly influenced by particle size and other factors.

Several lung models of varying degrees of complexity have been used to calculate the possible lung radiation absorbed dose that might be received by a miner working in an atmosphere of defined composition. The most detailed study of lung models was made by Altshuler *et al.*, who considered factors such as the site of deposition of radon daughters in the lung, the rate of clearance from the lung, and the thickness of the mucus layer in making calculations (4). These authors estimated that a miner exposed to a carefully defined atmosphere containing two-thirds of a working level of radon daughters¹ would receive an effective absorbed dose to the segmental bronchi of 24 rads per year from mouth breathing, or 13 rads per year from nose breathing. Such studies are of great assistance in understanding the interaction of the many factors which affect the absorbed dose of radiation delivered to lung tissue, as they point out areas which require investigation. It must be kept in mind, however, that they are based on many assumptions and are valid only if the actual conditions are in accord with those which were assumed to exist. Unfortunately, it is probable that in many instances the assumptions do not agree with the actual conditions. In addition to the factors that affect the composition of the radioactive aerosol, lung clearance mechanisms are known to be altered by

many air pollutants. Ciliated cells may be injured and lose their function, thereby permitting the accumulation of particles in localized areas of the bronchi with resultant changes in viscosity and thickness of the mucus layer. Pathological studies of the lungs of uranium miners have shown that there are many areas showing dysplasia, which may be caused by radiation or other air contaminants, or by a combination of all factors. Therefore, it is possible for two men working in the same atmosphere to receive widely different effective absorbed doses of radiation.¹

The problem of controlling the exposures of uranium miners to radon-222 and its daughters is different from the problem that exists in other parts of the nuclear energy industry. In most industrial situations, the sources of atmospheric contamination are limited in area, but in uranium mines the entire operation can be, and usually is, a source. Industrial situations are relatively constant, while in these mines the conditions change daily as new areas are opened and old workings are abandoned. Controls that are effective for one industrial operation are usually effective for a similar operation, but there is no "typical" uranium mine. These factors make the design and maintenance of control procedures a very difficult task.

As the entire area of a uranium mine is a source of radon-222, general dilution ventilation has been the method used to reduce the atmospheric concentrations of radon-222 and its daughters, and the general principles involved have been pointed out by Harris and Bales (5) and by Kusnetz (6). Examination of these theoretical considerations and experience shows limitations in the effectiveness of general ventilation for reduction of atmospheric concentrations of radon daughters. In a limited series of measurements in uranium mines, it was found that radon emanation rates varied from 0.5 μCi per minute per 1,000 cubic feet of mine volume to 35 μCi per minute per 1,000 cubic feet of mine volume, which means that the air ventilation required to reduce the concentrations of radon-222 and its daughters to any selected level would vary by a factor of about 8 (5). Engineering and economic requirements place limitations on

¹ The defined atmosphere contains 100 pCi of radon-222/liter and 200 pCi of total daughters per liter. The daughter concentrations are: polonium-218, 94 pCi/liter; lead-214, 62 pCi/liter; and bismuth-214, 44 pCi/liter. Forty percent of the activity is on particles less than 0.1 micron.

the quantities of air that can be moved in air courses, and physiological considerations limit the velocity of air currents in which men can work. Where large areas of high-grade ore are exposed, it may not be feasible to control exposure to radon daughters by dilution ventilation alone. However, the industry has been gaining experience and is now achieving levels of control that 5 years ago were considered by many to be unattainable. Table 3, which shows conditions in the third quarter of 1965, demonstrates the improvements that have been made.

Table 3. Estimates of environmental levels of radon-222 and its daughters in uranium mines, third quarter 1965

Multiple of working level	Percent of men affected *
<1	22
1-2.9	59
3-4.9	14
5-10	4
>10	1

* Total of 2,342

Maintenance of mine ventilation is a constant effort. Air doors and stoppings become defective and must be repaired. Fans and duct-work require replacement, and an educational campaign must be carried on to insure that the miners will use the ventilation that is provided. During the winter, this may be the most difficult part of the entire operation. Occasional high exposures will continue to occur because of mechanical or human failure, and it is unrealistic to expect that all working areas of any mine will always be in a satisfactory condition. Experiments on the use of water sprays, overpressurization of working areas, and filtration of air have been reported, but none of these procedures has been widely used to date (7,8).

The mining of uranium ores in the United States has resulted in exposing many thousands of men to dangerous amounts of radon-222 and its daughters. These exposures have caused an increased incidence of lung cancer in the miners and this increase is correlated with cumulative exposure to these elements. Efforts to control such exposures by State agencies and mine operators have improved conditions markedly, but much remains to be done to insure that radiation hazards in this segment of the nuclear energy industry are reduced to acceptable levels.

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Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. The total diet is the most direct measure of intake of radionuclides; however, since specific dietary data are not readily available, indicator foods may be used to estimate radionuclide intake. As fresh milk is: (1) consumed by a large segment of the U.S. population; (2) contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet; and (3) is the major source of dietary intake of short-lived radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analyses of the total diet or representative principal food items or groups, combined with appropriate consumption data.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming there is continuous exposure from intake by the population at large (1-3). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of

exposure (3). Additional guidelines are provided by the FRC Protective Action Guides (4) and by the International Commission of Radiological Protection (5,6).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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NATIONAL AND INTERNATIONAL MILK SURVEILLANCE

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, vari-

ous national and international organizations routinely monitor radionuclide levels in milk.

1. Pasteurized Milk Network November 1966

*National Center for Radiological Health and
National Center for Urban and Industrial
Health, PHS*

The Public Health Service's Pasteurized Milk Network (PMN) was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 sampling stations (figure 1) provides data on milk in every State, the

Canal Zone, and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1966 issue of *Radiological Health Data and Reports* (1).

The results for November 1966 and third quarter of 1966 are presented in table 1. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. When radionuclide values were below minimum detectable concentrations (1), averages were calculated using one-half the minimum detectable value; however, for iodine-131 and barium-140, zero was used for averaging purposes when concentrations were

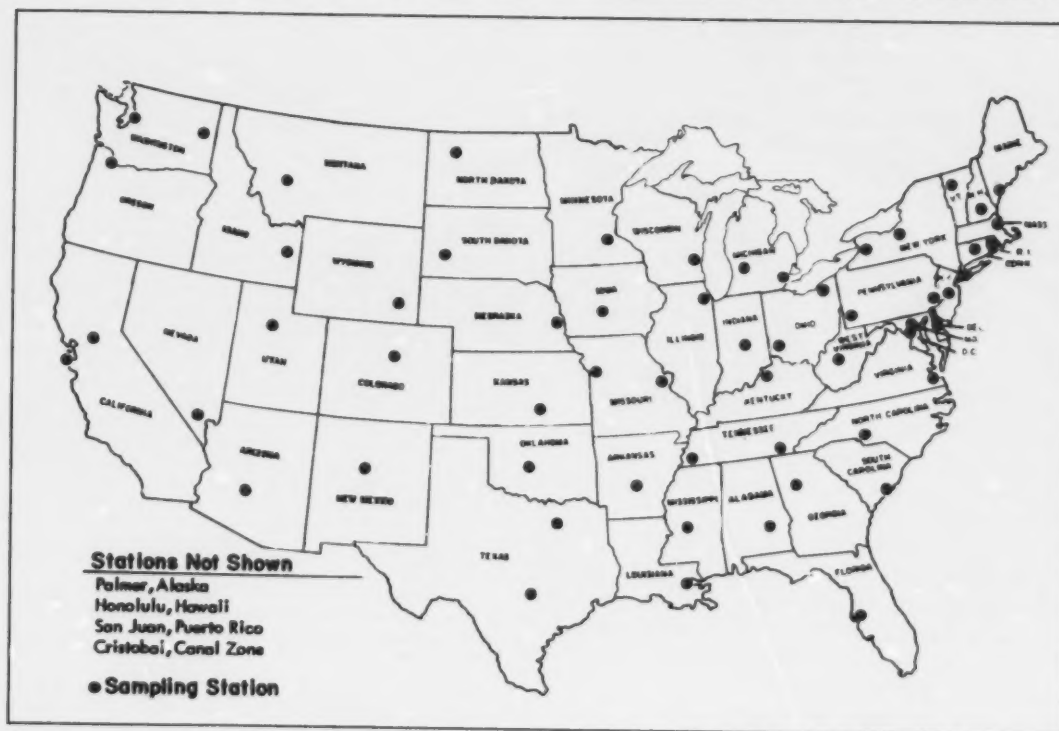


Figure 1. Pasteurized Milk Network sampling stations

Table 1. Average concentrations of radionuclides in pasteurized milk for the third quarter and November 1966

Sampling location		Concentration, pCi/liter									
		Strontium-90		Strontium-90		Iodine-131		Cesium-137		Barium-140	
		Third quarter 1966	November 1966 *	Third quarter 1966	November 1966	Third quarter 1966	November 1966	Third quarter 1966	November 1966	Third quarter 1966	November 1966
Ala:	Montgomery	<5	NA	12	12	0	0	20	15	0	0
Alaska:	Palmer	<5	<5	11	16	10	0	30	25	0	0
Ariz:	Phoenix	<5	<5	3	2	0	0	10	10	0	0
Ark:	Little Rock	<5	NA	24	26	0	0	25	20	0	0
Calif:	Sacramento	<5	<5	4	4	0	0	10	10	0	0
	San Francisco	<5	<5	4	3	0	0	15	10	0	0
C.Z:	Cristobal	<5	NA	4	7	0	0	15	25	0	0
Colo:	Denver	<5	<5	7	10	0	0	15	15	0	0
Conn:	Hartford	<5	<5	11	9	0	0	30	20	0	0
Del:	Wilmington	<5	<5	12	11	0	0	20	20	0	0
D.C.:	Washington	<5	NA	11	11	0	0	15	15	0	0
Fla:	Tampa	<5	NA	10	11	0	0	135	90	0	0
Ga:	Atlanta	<5	NA	19	15	0	0	35	25	0	0
Hawaii:	Honolulu	<5	<5	4	4	0	0	20	20	0	0
Idaho:	Idaho Falls	<5	<5	10	10	0	0	20	15	0	0
Ill:	Chicago	<5	<5	8	9	0	0	20	15	0	0
Ind:	Indianapolis	<5	<5	10	10	0	10	15	15	0	0
Iowa:	Des Moines	<5	<5	12	10	0	0	20	15	0	0
Kans:	Wichita	<5	<5	11	11	0	0	10	10	0	0
Ky:	Louisville	<5	NA	16	14	0	0	10	10	0	0
La:	New Orleans	<5	<5	32	27	0	0	55	30	0	0
Maine:	Portland	<5	<5	14	14	0	0	50	45	0	0
Md:	Baltimore	<5	NA	12	11	0	10	20	10	0	0
Mass:	Boston	<5	<5	15	13	0	0	45	35	0	0
Mich:	Detroit	<5	<5	9	9	0	0	20	15	0	0
Minn:	Grand Rapids	<5	<5	12	11	0	0	25	25	0	0
Miss:	Minneapolis	<5	<5	17	17	0	0	25	15	0	0
Miss:	Jackson	<5	NA	20	17	0	0	25	15	0	0
Mo:	Kansas City	<5	<5	13	11	0	0	10	10	0	0
	St. Louis	<5	<5	15	12	0	0	20	15	0	10
Mont:	Helena	<5	<5	10	10	0	0	25	20	0	0
Nebr:	Omaha	<5	<5	11	12	0	0	15	10	0	0
Nev:	Las Vegas	<5	<5	4	3	0	0	10	10	0	0
N.H.:	Manchester	<5	<5	18	15	0	0	75	50	0	0
N.J.:	Trenton	<5	<5	11	10	0	0	20	20	0	0
N. Mex:	Albuquerque	<5	<5	7	5	0	0	10	5	0	0
N.Y.:	Buffalo	<5	<5	10	9	0	0	25	20	0	0
	New York City	<5	<5	14	13	0	0	30	25	0	0
	Syracuse	<5	<5	10	9	0	0	25	20	0	0
N.C.:	Charlotte	<5	NA	21	21	0	0	25	20	0	0
N. Dak:	Minot	<5	<5	21	25	0	0	25	20	0	0
Ohio:	Cincinnati	<5	<5	11	10	0	0	15	10	0	0
	Cleveland	<5	<5	11	11	0	0	20	20	0	0
Okla:	Oklahoma City	<5	NA	12	9	0	0	10	10	0	0
Ore:	Portland	<5	<5	11	11	0	0	30	20	0	0
Pa:	Philadelphia	<5	<5	11	10	0	0	20	15	0	0
	Pittsburgh	<5	<5	15	14	0	10	25	20	0	0
P.R.:	San Juan	<5	NA	7	7	0	0	20	15	0	0
R.I.:	Providence	<5	<5	15	12	0	0	35	25	0	0
S.C.:	Charleston	<5	<5	20	19	0	0	50	30	0	0
S. Dak:	Rapid City	<5	<5	14	16	0	0	15	20	0	0
Tenn:	Chattanooga	<5	NA	20	17	0	0	25	15	0	0
Tex:	Memphis	<5	NA	16	14	0	0	10	10	0	0
	Austin	<5	NA	5	5	0	20	10	<5	0	0
	Dallas	<5	NA	11	10	0	0	10	10	0	0
Utah:	Salt Lake City	<5	<5	9	9	0	0	15	15	0	0
Vt:	Burlington	<5	<5	12	11	0	0	35	25	0	0
Va:	Norfolk	<5	NA	16	13	0	0	20	10	0	0
Wash:	Seattle	<5	<5	18	18	0	0	55	35	0	0
	Spokane	<5	<5	12	13	0	0	30	35	0	0
W. Va:	Charleston	<5	NA	14	16	0	0	15	15	0	0
Wis:	Milwaukee	<5	<5	8	9	0	0	20	15	0	0
Wyo:	Laramie	<5	<5	9	5	0	0	15	15	0	0
Network average		<5	<5	12.3	11.7	0	0	25	20	0	0

NA, no analysis.

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Table 2. Iodine-131 concentrations, pCi/liter,

Station location		November 1966														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ala:	Montgomery			<10							11					
Alaska:	Palmer								<10		<10					<10
Ark:	Phoenix			<10												
Calif:	Little Rock							<10							24	
	Sacramento				<10					<10						
	San Francisco			<10							<10					
C.Z:	Cristobal							<10							<10	
Colo:	Denver			<10								<10				
Conn:	Hartford				<10							<10				
Del:	Wilmington			<10							<10					
D.C:	Washington				<10						<10					
Fla:	Tampa			<10					<10							
Ga:	Atlanta		<10							<10						
Hawaii:	Honolulu	<10						<10								<10
Idaho:	Idaho Falls							<10							33	
Ill:	Chicago	<10							<10							13
Ind:	Indianapolis														26	
Iowa:	Des Moines			<10							<10					
Kans:	Wichita							<10						<10		
Ky:	Louisville	<10							<10							<10
La:	New Orleans			<10						<10						
Maine:	Portland							<10							<10	
Md:	Baltimore	<10								12						31
Mass:	Boston	<10							<10							<10
Mich:	Detroit	<10							11							12
	Grand Rapids							<10							13	
Minn:	Minneapolis	12						<10	<10							13
Miss:	Jackson														16	
Mo:	Kansas City				<10						37					
	St. Louis				14							<10				
Mont:	Helena		<10					<10								<10
Nebr:	Omaha				<10							<10				
Nev:	Las Vegas				<10						<10				<10	
N.H:	Manchester	<10								<10						<10
N.J:	Trenton	<10							<10							<10
N. Mex:	Albuquerque	<10							<10						<10	
N.Y:	Buffalo				<10											
	New York							<10							21	
	Syracuse		<10							<10						
N.C:	Charlotte							<10								<10
N. Dak:	Minot							<10							11	
Ohio:	Cincinnati							<10							20	
	Cleveland				<10						16					
Okla:	Oklahoma City	<10								<10					14	
Ore:	Portland				<10										<10	
Pa:	Philadelphia				<10											
	Pittsburgh	<10						<10								24
P.R:	San Juan							<10							<10	
R.I:	Providence	<10						<10								18
S.C:	Charleston	<10						<10								<10
S. Dak:	Rapid City							<10							<10	
Tenn:	Chattanooga			<10						<10	<10					
	Memphis			<10												
Tex:	Austin				<10											
	Dallas							<10							33	
Utah:	Salt Lake City							<10							<10	
Vt:	Burlington	<10							<10						<10	
Va:	Norfolk				<10							<10				
Wash:	Seattle			<10							<10					<10
	Spokane	<10									<10					
W. Va:	Charleston					<10						12				
Wis:	Milwaukee											<10				
Wyo:	Laramie		<10							<10						

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in individual milk samples, November 1966

November 1966—Continued															Station location	
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30		
	11					<10	<10						<10		Ala:	Montgomery.
	<10								<10						Alaska:	Palmer.
		<10			10							<10			Aria:	Phoenix.
	<10						<10					<10			Ark:	Little Rock.
															Calif:	Sacramento.
																San Francisco.
	<10				11			<10				<10			C.Z:	Cristobal.
		<10							<10						Colo:	Denver.
															Conn:	Hartford.
	12						15		<10						Del:	Wilmington.
	<10					<10									D.C:	Washington.
	<10													<10	Fla:	Tampa.
<10							<10							<10	Ga:	Atlanta.
					<10								<10		Hawaii:	Honolulu.
						<10								15	Idaho:	Idaho Falls.
	<10				14		22					12			Ill:	Chicago.
															Ind:	Indianapolis.
															Iowa:	Des Moines.
					<10							<10			Kana:	Wichita.
	<10					<10	<10						<10		Ky:	Louisville.
					<10							<10			La:	New Orleans.
						<10							<10		Maine:	Portland.
													<10		Md:	Baltimore.
													<10		Mass:	Boston.
					20							<10			Mich:	Detroit.
					<10		<10						<10			Grand Rapids.
	<10														Minn:	Minneapolis.
		<10					<10								Miss:	Jackson.
								<10		<10					Mo:	Kansas City.
																St. Louis.
		<10	<10										<10		Mont:	Helena.
							<10								Nebr:	Omaha.
						10							<10		Nev:	Las Vegas.
						<10								14	N.H:	Manchester.
													<10		N.J:	Trenton.
		<10							<10						N. Mex:	Albuquerque.
					<10							10			N.Y:	Buffalo.
15							<10							<10		New York.
							<10									Syracuse.
													<10		N.C:	Charlotte.
													<10		N. Dak:	Minot.
		12							<10				<10		Ohio:	Cincinnati.
																Cleveland.
		<10				<10									Okla:	Oklahoma City.
		12							11						Ore:	Portland.
						<10			<10						Pa:	Philadelphia.
													13		Pittsburgh.	
						<10									P.R:	Pittsburgh.
													<10		San Juan.	
															R.I:	Providence.
						<10							<10		S.C:	Charleston.
	<10						12								S. Dak:	Rapid City.
	14					<10									Tenn:	Chattanooga.
37																Memphis.
						<10									Tex:	Austin.
						<10							<10			Dallas.
													<10		Utah:	Salt Lake City.
						<10								<10	Vt:	Burlington.
	<10						<10		<10						Va:	Norfolk.
		<10													Wash:	Seattle.
																Spokane.
		<10								12					W. Va:	Charleston.
									<10						Wis:	Milwaukee.
<10							<10							<10	Wyo:	Laramie.

below minimum detectable levels. A similar procedure is used for the network average.

Individual iodine-131 milk concentrations for November are presented in table 2, and are presumed to reflect fallout from the Chinese mainland test of October 27, 1966. For comparative

purposes, distributions of strontium-90 and cesium-137 are presented in tables 3 and 4 for November 1965 and June through November 1966. The average strontium-90 concentrations in pasteurized milk from selected cities are presented in figure 2.

Table 3. Frequency distribution, strontium-90 concentrations in milk at Pasteurized Milk Network stations November 1965 and June-November 1966

Strontium-90 (pCi/liter)	Number of stations						
	1965	1966					
		Nov	June	July	Aug	Sept	Oct
Under 10.....	9	9	14	15	21	18	18
10-19.....	43	41	39	40	37	39	41
20-29.....	9	10	9	7	5	6	4
30-39.....	2	3	1	1	0	0	0

Table 4. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations November 1965 and June-November 1966

Cesium-137 (pCi/liter)	Number of stations						
	1965	1966					
		Nov	June	July	Aug	Sept	Oct
Under 50.....	57	56	56	56	61	62	61
50-99.....	5	6	6	6	1	0	2
100-149.....	1	1	1	1	1	1	0

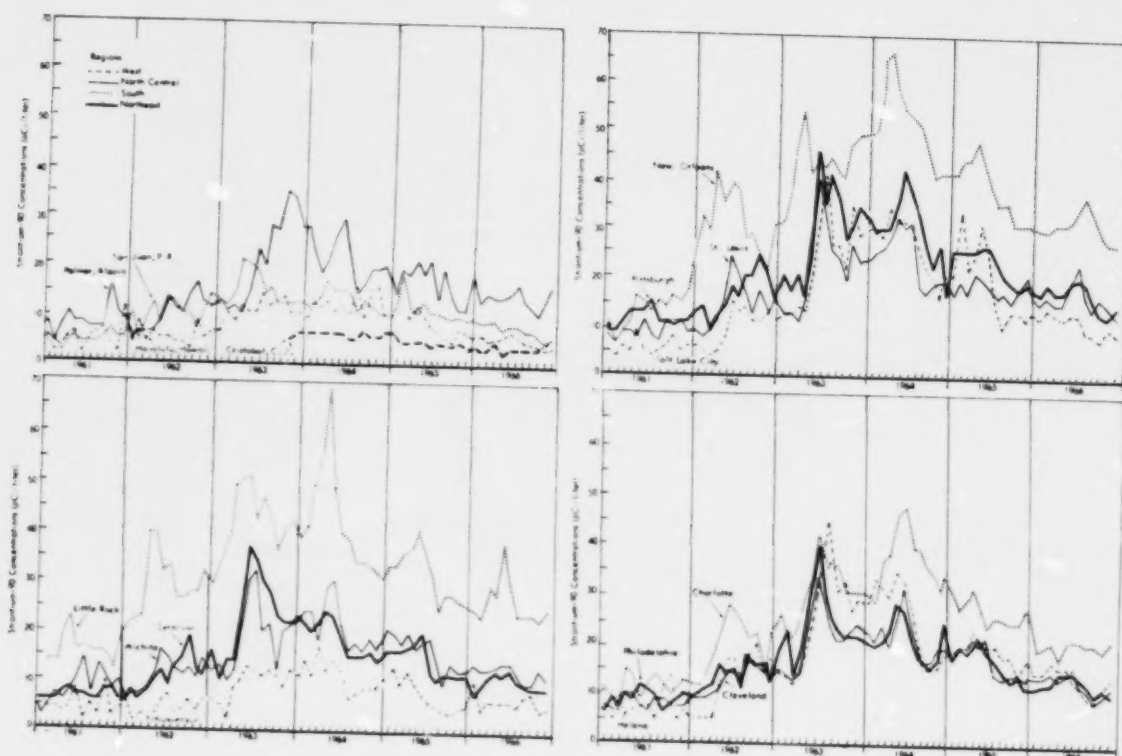


Figure 2. Strontium-90 concentrations in pasteurized milk, 1961-November 1966

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2. Canadian Milk Network November 1966¹

Radiation Protection Division
Department of National Health and Welfare

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine-131, and monthly composites are analyzed for strontium-90, cesium-137, and stable calcium and

¹ Prepared from December 1966 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

potassium. The analytical procedures were outlined in the December 1966 issue of *Radiological Health Data and Reports* (2).

The November 1966 monthly average strontium-90, cesium-137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 5. Iodine-131 and strontium-89 concentrations were below minimum detectable levels.

Table 5. Stable elements and radionuclides in Canadian whole milk, November 1966

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary.....	1.16	1.4	13.1	27
Edmonton.....	1.12	1.4	11.4	38
Ft. William.....	1.11	1.5	18.0	47
Fredericton.....	1.09	1.5	16.8	44
Halifax.....	1.13	1.5	16.3	37
Montreal.....	1.08	1.5	12.0	37
Ottawa.....	1.13	1.5	8.9	24
Quebec.....	1.08	1.6	17.4	60
Regina.....	1.14	1.5	12.7	24
St. John's, Nfld.....	1.09	1.5	17.8	56
Saskatoon.....	1.12	1.5	13.1	29
Sault Ste. Marie.....	1.07	1.5	15.1	39
Toronto.....	1.12	1.5	7.1	24
Vancouver.....	1.19	1.4	20.6	84
Windsor.....	1.15	1.5	5.8	18
Winnipeg.....	1.11	1.6	9.4	31
Average.....	1.12	1.5	13.5	39

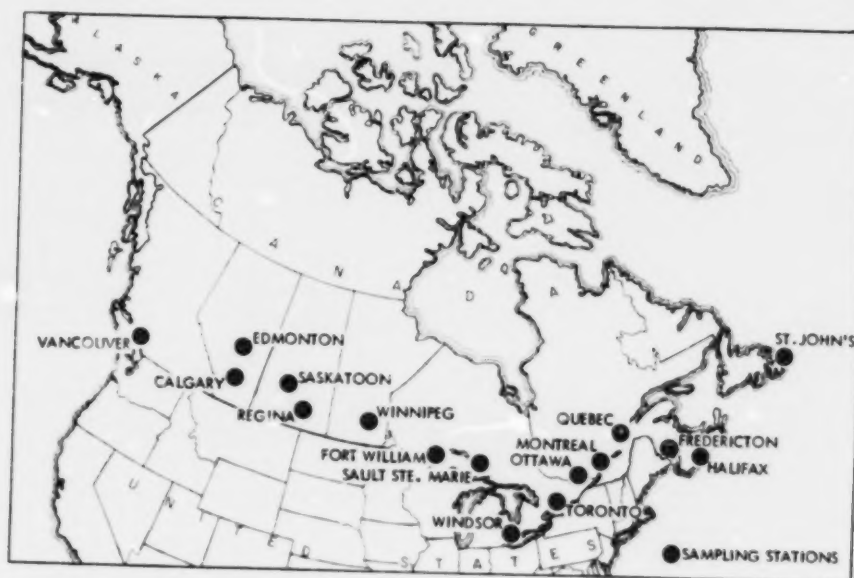


Figure 3. Canadian milk sampling stations

3. Pan American Milk Sampling Program November 1966

*Pan American Health Organization and
U.S. Public Health Service*

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between both agencies, air and milk sampling activities are conducted by a number of PAHO-member countries (figure 4). Results of the milk-sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (3).

Table 6 presents stable potassium, strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 monthly average concentrations for November 1966.



Figure 4. Pan American Milk Sampling Program locations

Table 6. Stable element and radionuclide concentrations in PAHO milk, November 1966

Sampling station	Number of samples	Potassium (g/liter)	Strontium-89 (pCi/liter) *	Strontium-90 (pCi/liter)	Iodine-131 (pCi/liter)	Cesium-137 (pCi/liter)	Barium-140 (pCi/liter) *
Chile: Santiago.....	8	1.62	15	1	16	4	10
Colombia: Bogota.....	1	1.50	10	3	<10	10	<10
Ecuador: Guayaquil.....	1	1.53	15	<1	<10	<5	<10
Zone 2.....	1	1.49	15	<1	<10	<5	<10
Jamaica: Kingston.....	NS						
Mandeville.....	1	1.41	5	7	<10	135	20
Montego Bay.....	NS						
Venezuela: Caracas.....	NS						
Canal Zone: Cristobal ^b				7		25	
Puerto Rico: San Juan ^b				7		15	

* Data have been corrected for decay to the date of sample collection.

^b For comparison purposes, the radionuclide concentrations at Cristobal, Canal Zone, and San Juan, Puerto Rico, are presented.

NS, no sample collected

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4. Radiostrontium in milk: January-June 1966

*Health and Safety Laboratory
U.S. Atomic Energy Commission*

In 1954, the Health and Safety Laboratory began monitoring strontium-90 in liquid whole milk in New York City to estimate the dietary contribution from ingestion of radiostrontium in milk. Subsequently, powdered milk monitoring was initiated at Perry, N.Y. (1954), and at Mandan, N. Dak. (1955). Liquid whole milk monitoring was started in Honolulu, Hawaii, in August 1959. Sampling was terminated at Mandan, N. Dak., and Honolulu, Hawaii, at the end of June 1965.

The New York City sample is a monthly composite of pasteurized milk purchased daily in quart containers at retail stores. Five large dairies are represented in the sample. The Perry samples are monthly composites of powdered whole milk for human consumption collected weekly in 5-pound lots from plants in the city. The strontium-90-to-calcium ratios in whole milk are presented in table 7.

² Data summarized from "Fallout Program Quarterly Summary Report, HASL 174," available from Clearinghouse for Federal Scientific and Technical Information, 5285 Port Royal Road, Springfield, Va. 22151.

**Table 7. Strontium-90-to-calcium ratios in milk
January-June 1966**

Sampling location	Strontium-90-to-calcium ratios (pCi ⁹⁰ Sr/g Ca)					
	Jan	Feb	Mar	Apr	May	June
New York, N.Y. (liquid whole milk)	13.0	14.3	13.0	11.5	13.8	17.0
Perry, N.Y. (powdered whole milk)	12.4	11.2	11.0	10.8	11.8	13.9

Recent coverage in Radiological Health Data and Reports:

Period	Issue
January-December 1964	June 1965
January-March 1965	September 1965
April-June 1965	March 1966
July-December 1965	June 1966

REFERENCES:

- (1) PUBLIC HEALTH SERVICE. Pasteurized Milk Network, August 1966. Radiol Health Data Rep 7: 698-701 (December 1966).
- (2) DEPARTMENT OF NATIONAL HEALTH AND WELFARE, RADIATION PROTECTION DIVISION. Canadian Milk Network, August 1966. Radiol Health Data Rep 7:702-703 (December 1966).
- (3) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1966. Radiol Health Data Rep 7:704 (December 1966).

STATE MILK SURVEILLANCE ACTIVITIES

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States now have progressed to a state of comprehensive environmental surveillance programs supported by functional radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk sur-

veillance activities. State milk surveillance activities are continually undergoing developmental changes. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

In addition to the State milk networks presented herein, programs recently covered in *Radiological Health Data and Reports* include:

<u>State milk network</u>	<u>Period reported</u>	<u>Last presented</u>
Colorado	May 1965-June 1966	October 1966
Connecticut	July-September 1966	February 1967
Florida	July-September 1966	January 1967
Indiana	July-September 1966	February 1967
Michigan	July-September 1966	February 1967
Minnesota	July-September 1966	February 1967
Oklahoma	July-September 1966	January 1967
New York	January-June 1966	November 1966
Pennsylvania	July-September 1966	February 1967
Texas	July-September 1966	January 1967

1. California Milk Network July-September 1966

*Division of Environmental Sanitation
Department of Public Health
State of California*

Surveillance of specific radionuclides in milk is one phase of the California Department of Health program on radiation control. This milk-monitoring function has been conducted at eight milksheds since January 1960 by the Department's Bureau of Radiological Health. With the addition of the Del Norte and Mendocino milksheds to the program in March 1962, weekly, biweekly, or monthly sampling of pasteurized

milk has been conducted at 10 major milksheds (figure 1). The original sampling locations were chosen by the State Department of Agriculture as representative of those where milk is consumed by a high percentage of the State's population. A description of the various California milksheds was presented earlier by Heslep and Cornish (1).

Strontium-89 and strontium-90 concentrations are determined radiochemically. Potassium-40, iodine-131, cesium-137, and barium-140 in whole fluid milk are determined by gamma-scintillation spectrometry. A detailed description of the analytical procedures was presented earlier (2).

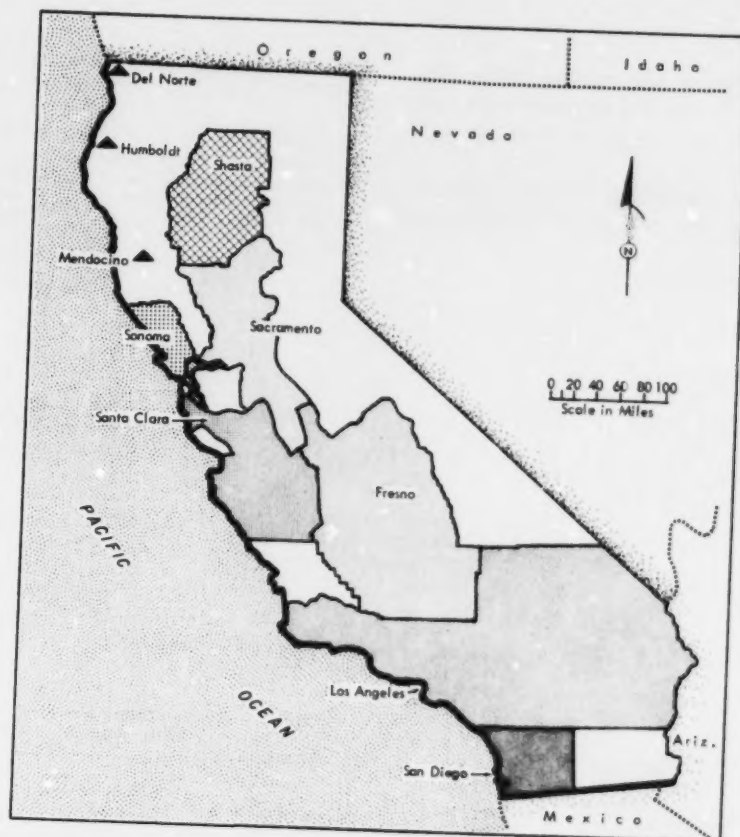


Figure 1. California milksheds

Table 1. Stable elements and radionuclides in California milk, July-September 1966

Element and month	Del Norte	Fresno	Humboldt	Los Angeles	Mendocino	Sacramento	San Diego	Santa Clara	Shasta	Sonoma	Average
Calcium (g/liter)											
July	NS	1.15	1.22	1.10	1.14	1.19	1.10	1.04	1.12	1.19	1.13
August	1.23	1.09	1.19	1.08	1.21	1.13	1.09	1.11	1.10	1.19	1.14
September	1.22	1.17	1.20	1.09	1.17	1.18	1.13	1.15	1.13	1.24	1.17
Potassium-40 (pCi/liter)											
July	NS	1,190	1,100	1,230	1,220	1,100	1,190	1,250	1,270	1,240	1,200
August	1,220	1,220	1,160	1,230	1,220	1,200	1,190	1,250	1,220	1,310	1,220
September	1,140	1,200	1,170	1,210	1,240	1,170	1,200	1,360	1,250	1,220	1,230
Strontium-89 (pCi/liter)											
July	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	—
August	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	—
September	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	—
Strontium-90 (pCi/liter)											
July	NS	3	6	2	4	4	3	2	5	4	3.6
August	16	5	2	1	1	1	2	3	3	1	3.5
September	9	4	6	3	4	4	3	3	5	3	4.6
Cesium-137 (pCi/liter)											
July	NS	15	11	*7	*6	10	7	11	12	9	9.8
August	18	12	*6	*6	14	10	ND	11	11	13	10.6
September	15	*4	10	*3	*2	*5	ND	*4	9	*6	6.4

* When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant.
 NS, no sample collected
 ND, nondetectable

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The monthly calcium and radionuclide concentrations in California pasteurized milk are given in table 1 for the period of July to September 1966.

Network average strontium-90 and cesium-137 concentrations are presented graphically in figure 2.

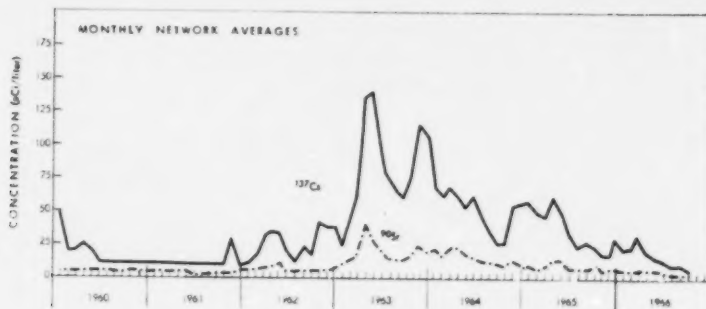


Figure 2. Radionuclide concentrations in California milk 1960-September 1966

2. Oregon Milk Network July-September 1966

*Division of Sanitation and Engineering
Oregon State Board of Health*

The Oregon State Board of Health has monitored radionuclide concentrations in milk since March 1962. As part of this program routine milk samples are collected at eight major production areas (figure 3), which supply 90 percent of the milk distributed in Oregon. Currently, pasteurized milk samples are collected monthly by the Oregon Department of Agriculture, except in the Portland area where weekly samples are collected by the city of Portland. The milk-sampling frequency is accelerated to a weekly basis in areas where iodine-131 concentrations exceed 100 pCi/liter, or where cesium-137 concentrations exceed 500 pCi/liter. Strontium-90 analyses are performed on a bimonthly basis, but may be done monthly when significant increases are observed.

Strontium-90 concentrations are determined using a trichloroacetic acid analytical procedure (5). Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma-scintillation spectrometry (4).

Recent coverage in *Radiological Health Data and Reports*:

Period

Annual summary 1964
Annual summary 1965
January-March 1966
April-June 1966

Issue

June 1966
June 1966
September 1966
December 1966

Table 2. Radionuclide concentrations in Oregon milk July-September 1966

Location	Sampling frequency	Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
		July	Aug	Sept	July	Aug	Sept
Baker.....	M	11	NA	6	15	20	20
Coos Bay.....	M	13	NA	16	15	45	20
Eugene.....	M	NA	NA	5	30	35	25
Medford.....	M	8	NA	6	30	40	40
Nyssa.....	M	14	NA	NS	15	15	NS
Portland composite.....	W	16	14	10	27	33	28
Portland local.....	W	NA	NA	12	44	42	28
Redmond.....	M	10	NA	8	30	40	20
Tillamook.....	M	17	NA	12	60	85	40
Average.....	—	13	14	9	28	39	28

M, sampled monthly
W, sampled weekly
NA, no analysis
NS, no sample collected

Table 2 gives the strontium-90 and cesium-137 concentrations in pasteurized milk from July through September 1966. These data are presented graphically in figure 4. Iodine-131 and barium-140 concentrations remained below minimum detectable levels of 15 pCi/liter.

Recent coverage in *Radiological Health Data and Reports*:

Period

Annual summary 1965
January-March 1966
April-June 1966

Issue

June 1966
September 1966
December 1966

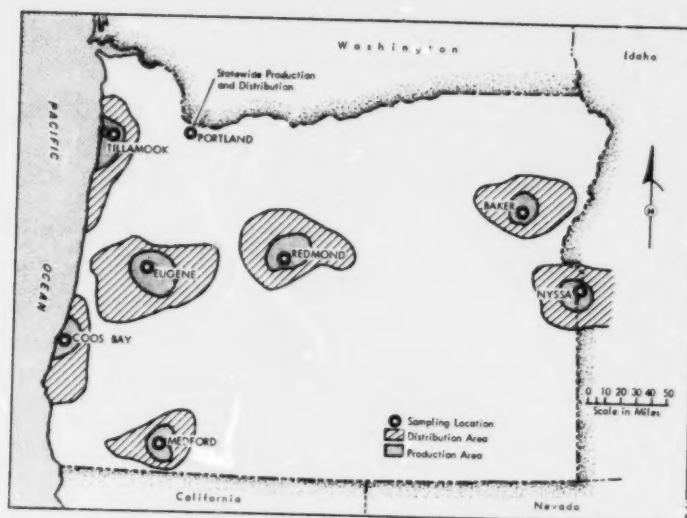


Figure 3. Oregon milk production and distribution areas

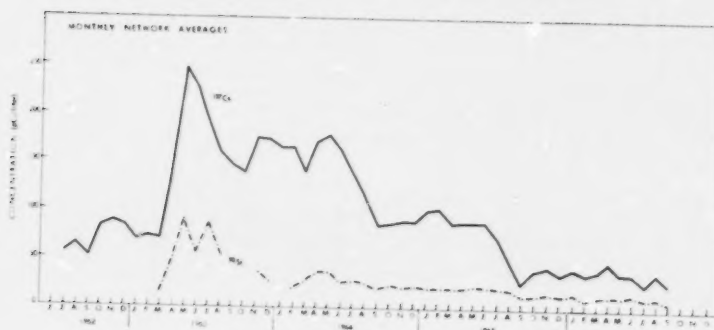


Figure 4. Radionuclide concentrations in Oregon milk network, June 1962-September 1966

3. Washington Milk Network July-September 1966

*Air Sanitation and Radiation Control Section
State of Washington Department of Health*

The Washington State Department of Health initiated a surveillance program for radioactivity in raw milk in December 1962. The collection points shown in figure 5 were selected to provide samples representative of varying climatological conditions within the State's two major milksheds. In addition to the eight milk

sampling locations in Washington, milk is sampled from Northwest Idaho (Sandpoint), as this area forms a part of the Spokane milkshed.

Selected samples are analyzed radiochemically for strontium-90, Potassium-40, iodine-131, cesium-137, and barium-140 concentrations are determined by gamma-scintillation spectrometry. Details of the analytical procedures were presented earlier (5).

Table 3 presents monthly radionuclide concentrations in Washington raw milk for July through September 1966. During this period, iodine-131 and barium-140 concentrations remained below minimum detectable levels of 10

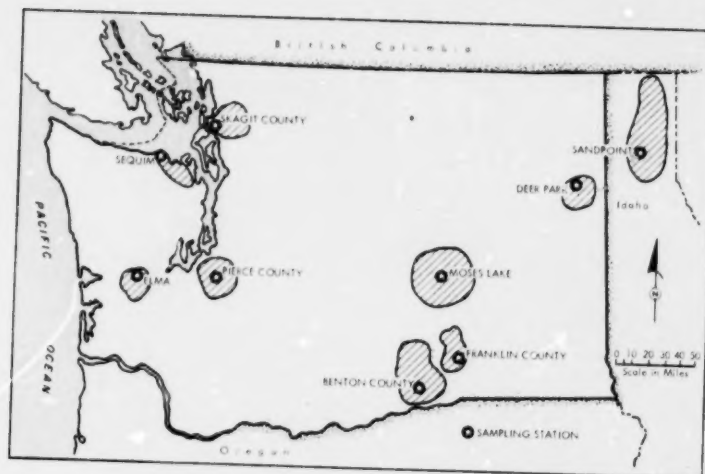


Figure 5. Washington milksheds and sampling locations

Table 3. Radionuclide concentrations in Washington milk, July-September 1966

Sampling location	Potassium-40, pCi/liter			Strontium-90, pCi/liter			Cesium-137, pCi/liter		
	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept
Benton County	NS	1,290	NS	NS	6	NS	NS	19	NS
Deer Park	1,300	1,170	1,020	10	11	NS	38	39	31
Elma	1,370	1,180	1,340	21	9	7	96	68	49
Franklin County	1,160	NS	1,300	5	NS	4	24	NS	15
Moses Lake	NS	1,240	1,270	NS	6	5	NS	31	<15
Pierce County	1,170	1,190	1,210	15	13	9	73	40	35
Sandpoint	1,300	1,300	1,220	NA	30	22	91	69	46
Sequim	1,210	1,190	1,170	9	6	4	45	31	25
Skagit County	1,170	1,320	1,150	17	15	10	57	39	33
Average	1,240	1,240	1,210	13	12	9	61	42	31

NS, no sample collected
NA, no analysis performed

and 15 pCi/liter, respectively. Monthly average strontium-90 and cesium-137 concentrations are presented graphically in figure 6, to display general trends.

Zinc-65 was identified in the Benton-Franklin area on one occasion during this period (table 4). This nuclide has appeared periodically in this area as a result of the irrigation of

some pasture land with Columbia River water which has been shown to contain this radionuclide.

Table 4. Milk samples in Washington State containing zinc-65

Sampling location	Collection date, 1966	Zinc-65 (pCi/liter)
Franklin County	July 6	<25
Benton County	August 2	<25
Franklin County	September 7	109

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
Annual summaries 1964 and 1965	June 1966
January-March 1966	September 1966
April-June 1966	December 1966

Radiological Health Data and Reports

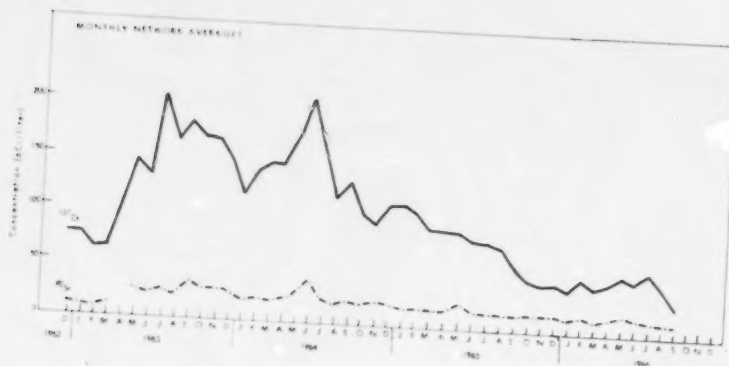


Figure 6. Radionuclide concentrations in Washington milk December 1962-September 1966

REFERENCES

- (1) HESLEP, J. M., and A. C. CORNISH. California milk network and milkshed comparisons, April-June 1963. Radiol Health Data 4:596-599 (December 1963).
- (2) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH. California milk network, 1960-June 1962. Radiol Health Data 4:90-92 (February 1963).
- (3) MURTHY, G. K., J. E. COAKLEY, and J. E. CAMPBELL. A method for the elimination of ashing in strontium-90 determinations in milk. J Dairy 43:151-154 (1960).
- (4) OREGON STATE BOARD OF HEALTH, DIVISION OF SANITATION AND ENGINEERING. Oregon milk network, April-June 1965. Radiol Health Data 6:683-684 (December 1965).
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FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in routine operation and reported periodically include: (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy

Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are listed below:

Program	Period reported	Last presented
California Diet	January-April 1965	January 1967
Connecticut Standard Diet	July 1965-June 1966	November 1966
Institutional Diet, PHS	April-June 1966	January 1967
Teenage Diet, FDA	February-November 1965	August 1966
Tri-City Diet, HASL	February-April 1966	December 1966

March 1967

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1. Cesium-137 in Tri-City Diets, 1965¹

Health and Safety Laboratory
U.S. Atomic Energy Commission

The amount of cesium-137 in the human body can be measured with whole-body counters. The results of such measurements on certain Alaskan Eskimos with relatively high body burdens have been reported (1,2). Comprehensive reports of the results of such measurements in the conterminous United States have not appeared in the literature recently. To estimate the average cesium-137 body burdens of people living in large metropolitan areas, the Health and Safety Laboratory (HASL) of the U.S. Atomic Energy Commission has relied on indirect evidence based on estimates of the cesium-137 content in the diet. These estimates of total intake of cesium-137 are in turn based on the analyses of food samples obtained as part of the Tri-City diet studies (3).

In 1961, Brar, Gustafson, and Muniak (4) began measuring by gamma-ray spectrometry the cesium-137 content in foods purchased in Chicago as part of the Tri-City diet program. In late 1964, it was decided that cesium-137 analyses of foods obtained in the Tri-City diet studies might provide additional useful information on the cesium-137 content in the diet in New York and San Francisco, as well as in Chicago. Ashed samples of these foods were analyzed by wet chemistry. Because the foods obtained for the program were ashed at high temperatures, it was likely that some of the cesium-137 in the samples was volatilized before the analyses were performed. To correct for these losses, the average loss for each diet category was computed by comparing the HASL results with those obtained by Brar *et al.* on identical unashed samples purchased in Chicago in 1965. These were averaged and applied to correct the data obtained on the samples from New York City and San Francisco, as well as from Chicago. Results of the analyses

along with estimates of daily intakes of cesium-137 at the three cities are shown in tables 1 to 3.

The geographical variation of cesium-137 diet levels was similar to that observed for strontium-90. The highest levels were found in the New York City diet, the lowest levels in the San Francisco diet, and intermediate levels in the Chicago diet. If this pattern is constant, then the quarterly estimates of cesium-137 diet levels made by Brar *et al.* since 1961 can be used to approximate diet levels in New York City and in San Francisco.

The daily intake of cesium-137 from milk, meat, cereals, fruits, and vegetables, as calculated from the data in tables 1 to 3, along with the percentage intake from these sources, are shown in table 4. As noted by others in previous years, most of the cesium-137 ingested is obtained from meat or dairy products. As pointed out by Gustafson (5), however, the concentration of cesium-137 is decreasing in milk at a greater rate than in other dietary components. Thus the relative importance of milk as a source of cesium-137 in diet is diminishing. This trend, observed in 1965, is assumed to have persisted through 1966.

Body burdens

If it is assumed that the retention of cesium-137 in the body follows a single exponential law, and that 100 percent of the ingested cesium-137 is absorbed (6), then the body burden at any time after ingestion is given by the equation:

$$Q = Q_0 e^{-\lambda t} + \frac{P}{\lambda} (1 - e^{-\lambda t}) \quad (1)$$

where Q is the body burden, λ is the biological decay constant for cesium-137 in the body, and P is the daily intake of cesium-137. If a biological half-life of 3 months (90 days) is assumed, and the estimated daily intakes of cesium-137 at each city are P_1 , P_2 , P_3 , and P_4 for the first, second, third, and fourth quarters of the year, respectively, then one obtains:

$$Q_1 = \frac{Q_0}{2} + \frac{P_1}{2\lambda} = \frac{Q_0}{2} + 65 P_1, \quad (2)$$

or in general,

$$Q_n = \frac{Q_{n-1}}{2} + 65 P_n, \quad (3)$$

¹ Material authored by Mr. J. Rivera from "Fallout Program Quarterly Summary Report, HASL-174, January 1, 1967." Available from the Clearinghouse for Federal Scientific and Technical Information, 5285 Port Royal Road, Springfield, Va. 22151.

Table 1. Cesium-137 in Tri-City diets, New York City, 1965*

Food category	Intake (kg/yr)	Feb 1965		May 1965		Nov 1965	
		pCi/kg	pCi/yr	pCi/kg	pCi/yr	pCi/kg	pCi/yr
Milk	221	107	23,600	109	24,100	35	7,700
Meat	73	338	25,000	286	21,000	276	20,000
Poultry	17	37	630	40	680	50	850
Fresh fish	8	85	700	110	900	174	1,000
Shellfish	1	10	10	8	8	9	9
Eggs	16	13	210	20	320	20	320
Bakery products	37	127	4,700	132	4,900	83	3,100
Whole grain products	11	181	2,000	177	1,900	156	1,700
Flour	43	95	4,100	105	4,500	48	2,100
Rice	3	65	200	50	100	60	200
Macaroni	3	194	600	216	600	146	400
Fresh vegetables	43	48	2,100	83	3,600	179	7,700
Canned vegetables	20	14	280	10	200	9	180
Root vegetables	17	9	200	10	200	14	200
Potatoes	45	30	1,400	28	1,300	25	1,100
Dried beans	3	103	300	135	400	59	200
Fresh fruit	68	25	1,700	35	2,400	37	2,500
Canned fruit	26	39	1,000	45	1,200	56	1,500
Fruit juices	19	35	660	89	1,700	65	1,200
pCi/yr			60,390		70,008		51,959
pCi/day			190		192		142

* No analyses for third quarter 1965 (August 1965).

Table 2. Cesium-137 in Tri-City diets, Chicago, 1965

Food category	Intake (kg/yr)	Jan 1965		Apr 1965		July 1965		Oct 1965	
		pCi/kg	pCi/yr	pCi/kg	pCi/yr	pCi/kg	pCi/yr	pCi/kg	pCi/yr
Milk	221	72	16,000	95	21,000	40	8,800	43	9,500
Meat	73	213	16,000	174	13,000	159	12,000	145	11,000
Poultry	17	42	710	41	700	32	540	59	1,000
Fresh fish	8	317	3,000	282	2,000	86	700	677	5,000
Shellfish	1	9	9	5	5	10	10	15	20
Eggs	16	15	240	13	200	15	240	18	290
Bakery products	37	136	5,000	127	4,700	109	4,000	110	4,100
Whole grain products	11	233	2,600	191	2,100	246	2,700	306	3,400
Flour	43	73	3,100	92	4,000	79	3,400	87	3,700
Rice	3	136	400	62	200	48	100	120	400
Macaroni	3	231	700	172	500	189	600	29	90
Fresh vegetables	43	67	2,900	31	1,300	12	520	26	1,100
Canned vegetables	20	14	280	6	100	9	200	13	260
Root vegetables	17	3	50	6	100	3	50	13	220
Potatoes	45	1	40	10	450	4	200	19	860
Dried beans	3	39	100	29	90	60	200	99	300
Fresh fruit	68	62	4,200	22	1,500	23	1,600	18	1,200
Canned fruit	26	40	1,000	23	600	38	950	41	1,100
Fruit juices	19	73	1,400	47	900	64	1,200	71	1,300
pCi/yr			57,729		53,445		38,050		44,840
pCi/day			158		146		104		123

where Q_n is the body burden at the end of the n th quarter and P_n is the daily intake during the n th quarter.

From graphical analysis of the data obtained during 1965, the estimated daily intakes of cesium-137 for each quarter of the year were determined and are given in table 5.

Monthly measurements of the cesium-137 body burdens of two subjects made at HASL during 1965 showed a body burden of about 20 nCi early in the year; this declined to about

15 nCi by the end of the year.² From measurements of Miller, quoted by Gustafson (5), on Argonne National Laboratory personnel, the body burden of Chicago residents at the start of 1965 was about 14 nCi of cesium-137. No estimates are available for body burdens of San Francisco residents at the start of 1965, but a reasonable estimate from the relationship of diet contamination among the three cities

² Personal communication with L. C. Charlton.

Table 3. Cesium-137 in Tri-City diets, San Francisco, 1965

Food category	Intake (kg/yr)	Mar 1965		June 1965		Sept 1965		Dec 1965	
		pCi/kg	pCi/yr	pCi/kg	pCi/yr	pCi/kg	pCi/yr	pCi/kg	pCi/yr
Milk	221	74	16,000	73	16,000	20	4,400	20	4,400
Meat	73	308	22,000	185	14,000	93	6,800	209	15,000
Poultry	17	23	390	39	660	50	850	39	660
Fresh fish	8	56	400	97	800	11	90	61	500
Shellfish	1	8	8	8	8	8	8	35	40
Eggs	16	15	240	4	60	9	100	16	260
Bakery products	37	69	2,600	58	2,100	84	3,100	86	3,200
Whole grain products	11	87	960	50	550	153	1,700	105	1,200
Flour	43	54	2,300	26	1,100	64	2,800	27	1,200
Rice	3	77	200	58	200	111	300	45	100
Macaroni	3	129	400	133	400	224	700	122	400
Fresh vegetables	43	32	1,400	27	1,200	5	400	29	1,200
Canned vegetables	20	6	100	3	60	3	60	6	100
Root vegetables	17	12	200	2	30	6	100	10	170
Potatoes	45	5	200	6	300	15	680	6	300
Dried beans	3	49	100	50	200	49	100	53	200
Fresh fruit	68	16	1,100	14	950	45	3,100	63	4,300
Canned fruit	26	18	470	24	620	32	830	22	570
Fruit juices	19	34	650	27	510	62	1,200	53	1,000
pCi/yr			49,718		39,748		27,318		34,800
pCi/day			136		109		75		95

Table 4. Sources of cesium-137 in Tri-City diets, 1965

Food category	New York City					
	Feb 1965		May 1965		Nov 1965	
	pCi/day	Percent of ¹³⁷ Cs intake	pCi/day	Percent of ¹³⁷ Cs intake	pCi/day	Percent of ¹³⁷ Cs intake
Milk	64	34	67	35	22	15
Meat	72	38	63	33	62	43
Cereals	32	17	32	17	20	14
Fruits	9	5	13	7	14	10
Vegetables	11	6	15	8	26	18
pCi/day	189		191		144	

Food category	Chicago					
	Jan 1965		Apr 1965		July 1965	
	pCi/day	Percent of ¹³⁷ Cs intake	pCi/day	Percent of ¹³⁷ Cs intake	pCi/day	Percent of ¹³⁷ Cs intake
Milk	44	25	57	39	24	23
Meat	51	33	44	30	36	35
Cereals	33	21	32	22	30	29
Fruits	19	12	9	6	10	10
Vegetables	9	6	6	4	3	3
pCi/day	156		146		103	

Food category	San Francisco					
	Mar 1965		June 1965		Sept 1965	
	pCi/day	Percent of ¹³⁷ Cs intake	pCi/day	Percent of ¹³⁷ Cs intake	pCi/day	Percent of ¹³⁷ Cs intake
Milk	44	32	44	41	12	16
Meat	64	46	41	38	22	29
Cereals	18	13	12	11	23	31
Fruits	6	4	5	5	14	19
Vegetables	6	4	4	4	4	5
pCi/day	139		108		75	

Table 5. Estimated daily intakes of cesium-137, Tri-City diets, by quarters for 1965

City	Daily intakes (pCi/day)			
	First quarter	Second quarter	Third quarter	Fourth quarter
New York City	190	180	160	150
Chicago	150	125	115	130
San Francisco	145	110	85	90

Table 6. Calculated body burdens of cesium-137, by quarters for 1965

City	Body burdens (nCi)				
	Start of 1965	First quarter	Second quarter	Third quarter	Fourth quarter
New York City	20	22	23	22	22
Chicago	15	17	17	16	16
San Francisco	10	14	14	13	13

is about 10 nCi. Substituting these three estimates of Q_i (20, 14, and 10 nCi for New York City, Chicago, and San Francisco, respectively), and the estimates of P_1 , P_2 , P_3 , and P_4 , the body burdens at the end of each quarter of 1965 for the three cities were calculated using equation (3), and are given in table 6. Based on these calculations it would appear that during 1965 the average cesium-137 body burdens of New York City, Chicago, and San Francisco residents remained virtually constant. It is expected that the decline in cesium-137 diet levels observed during the latter half of 1965 should be reflected in declining body burdens during 1966. It should be kept in mind that the rate of decline for individuals will depend to some extent on the amount of milk that they consume. Individuals normally consuming large amounts of milk will experience a faster decline in body burdens than those consuming less milk.

Summary and conclusion

The best method for determining the cesium-137 content in people is probably by direct measurements using whole-body counters. The next best method is by analyzing foods for cesium-137 by gamma-ray spectrometry or by radiochemistry on wet-ashed samples, and estimating from these analyses the total dietary

intake. Chiefly because of the ready availability of the samples and the obvious need for more information on the subject, HASL has analyzed dry-ashed food samples for cesium-137, attempted to correct the results for losses during ashing by volatilization, and used the results to estimate the total dietary intake. Because the correction factors turned out to be quite variable, this approach was not very satisfactory, and has been discontinued. Despite the shortcomings of the method the following conclusions have been reached, and are thought to be valid:

1. Estimates of the daily intake of cesium-137 made from measurements of the cesium-137 content in foods purchased in New York City, Chicago, and San Francisco during 1965 ranged from 85 pCi/day in San Francisco to 190 pCi/day in New York City. The results of measurements made in one city (e.g., Chicago) can be used to infer the diet levels in the other two cities.

2. Body burdens of cesium-137 can be inferred from dietary intake estimates. At the end of 1965, the body burden of cesium-137 in urban residents of the conterminous United States is estimated to have been about 16 nCi.

3. The major sources of cesium-137 in the diet during 1965 were from meat and milk. The relative importance of milk as a source was decreasing at the end of 1965 and this trend is expected to continue during 1966.

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Section II. Water

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and of specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values in treated water or dissolved solids fractions of raw surface water with the Public Health Service Drinking Water Standards (1). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (2-4), set the upper limits for approval of a drinking water supply containing radium-

226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the guides recommended by FRC for control action. In the known absence¹ of strontium-90 and alpha emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when more complete analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long range trends. Water programs previously reported in *Radiological Health Data and Reports* are listed below.

¹ Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium-90, respectively.

Program	Period reported	Last presented
California Water Sampling Program	July-December 1965	November 1966
Coast Guard Water Sampling Program	1965	November 1966
Colorado River Basin Sampling Network	1962-1964	November 1965
Drinking Water Analysis Program	1962	October 1965
Florida Water Sampling Program	1964	November 1965
Kentucky Water Sampling Program	May 1963-June 1964	March 1965
Lower Columbia River Radiological Survey in Oregon	August 1963-July 1964	October 1965
Minnesota Surface Water Sampling Program	July-December 1965	July 1966
New York Surface Water Sampling Program	June-December 1965	June 1966
North Carolina Water Sampling Program	1964	November 1965
Radiostrontium in Tap Water, HASL	May and July-November 1965	June 1966
Washington Surface Water Sampling Program	July 1964-June 1965	May 1966

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GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, SEPTEMBER 1966

*Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of Interior*

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as a part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the analysis for alpha- and beta-ray activity. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported quarterly. The stations on each river are arranged

in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the June 1966 issue of *Radiological Health Data and Reports*.

Data and sampling locations have been published for certain years (1-6); information for other periods is available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the



Figure 1. Sampling locations and associated total beta activity (pCi/liter) for surface waters, September 1966

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beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water

Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During September, the following stations showed alpha radioactivity in excess of 15 pCi/liter on either dissolved or suspended solids:

Arkansas River: Coolidge, Kans.

Table 1. Radioactivity in raw surface waters, September 1966

Station	Average beta radioactivity, pCi/liter			Average alpha radioactivity, pCi/liter			Station	Average beta radioactivity, pCi/liter			Average alpha radioactivity, pCi/liter		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total		Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:							Missouri River:						
Cedar Hill, N. Mex.	1	11	12	<1	2	2	Williston, N. Dak.	2	16	18	0	4	4
Arkansas River:							Bismarck, N. Dak.	1	14	15	0	3	3
Coolidge, Kans.	12	33	45	2	20	22	St. Joseph, Mo.	9	12	21	2	3	5
Ponca City, Okla.	19	17	36	4	1	5	North Platte River:						
Atchafalaya River:							Henry, Nebr.	5	30	35	0	19	19
Morgan City, La.	3	10	13	<1	1	1	Ohio River:						
Big Horn River:							Toronto, Ohio	1	12	13	0	0	0
Hardin, Mont.	3	20	23	1	7	8	Pend Oreille River:						
Chena River:							Albion Falls Dam,						
Fairbanks, Alaska	<1	3	3	0	0	0	Idaho	1	3	4	0	<1	<1
Clearwater River:							Platte River:						
Lewiston, Idaho	<1	2	2	0	0	0	Plattsmouth, Nebr.	13	16	29	4	2	6
Clinch River:							Rainy River:						
Clinton, Tenn.	1	3	4	0	0	0	Hauteville, Minn.	1	10	11	<1	0	<1
Kingston, Tenn.	1	6	7	0	0	0	Red River, North:						
Colorado River:							Grand Forks,						
Loma, Colo.	18	21	39	5	17	22	N. Dak.	2	24	26	0	1	1
Page, Ariz.	0	16	16	0	4	4	Red River, South:						
Parker Dam, Calif.							Alexandria, La.	1	14	15	0	1	1
Ariz.	0	13	13	0	4	4	Rio Grande:						
Columbia River:							El Paso, Tex.	15	16	31	4	4	8
Wenatchee, Wash.	0	3	3	0	0	0	Laredo, Tex.	200	12	212	47	3	50
Pasco, Wash.	48	318	366	0	0	0	San Joaquin River:						
Clatskanie, Ore.	7	25	32	0	<1	1	Vernalis, Calif.	3	6	9	1	8	9
Connecticut River:							San Juan River:						
Enfield Dam, Conn.	1	4	5	0	0	0	Shiprock, N. Mex.	101	14	115	31	3	34
Coosa River:							Savannah River:						
Rome, Ga.	1	3	4	0	0	0	Port Wentworth,						
Cumberland River:							Ga.	6	23	29	0	0	0
Cheatham Lock,							Snake River:						
Tenn.	0	4	4	0	0	0	Payette, Idaho	3	12	15	0	4	4
Delaware River:							Wawawai, Wash.	1	10	11	0	2	2
Philadelphia, Pa.	0	6	6	0	0	0	South Platte River:						
Great Lakes:							Julesburg, Colo.	130	54	184	43	32	75
Duluth, Minn.	0	3	3	0	0	0	Susquehanna River:						
Green River:							Conowingo, Md.	1	6	7	0	0	0
Dutch John, Utah	1	17	18	0	3	3	Tennessee River:						
Hudson River:							Chattanooga, Tenn.	0	6	6	0	0	0
Poughkeepsie, N.Y.	1	7	8	0	0	0	Wabash River:						
Illinois River:							New Harmony, Ind.	2	7	9	0	<1	<1
Peoria, Ill.	3	10	13	0	1	1	Yellowstone River:						
Grafton, Ill.	2	10	12	0	1	1	Sidney, Mont.	24	13	37	7	3	10
Kansas River:							Maximum	200	318	306	47	32	75
DeSoto, Kans.	13	14	27	4	2	6	Minimum	0	2	2	0	0	0
Klamath River:													
Keno, Ore.	<1	7	7	0	0	0							
Maumee River:													
Toledo, Ohio	1	8	9	0	0	0							
Mississippi River:													
St. Paul, Minn.	1	11	12	0	0	0							
E. St. Louis, Ill.	3	11	14	1	1	2							
New Roads, La.	2	12	14	0	2	2							
New Orleans, La.	1	10	11	0	1	1							

* Gross beta activity at this station may not be directly comparable to gross beta activity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides, common to all stations.

Colorado River: Loma, Colo.
North Platte River: Henry, Nebr.
Rio Grande: Laredo, Tex.
San Juan River: Shiprock, N. Mex.
South Platte River: Julesburg, Colo.

Beta radioactivity in excess of 150 pCi/liter on either dissolved or suspended solids appeared at Pasco, Wash., on the Columbia River; Laredo, Tex., on the Rio Grande; and Julesburg, Colo., on the South Platte River.

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Section III. Air and Deposition

RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta particle analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range

trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the results from the above networks was performed by Lockhart and Patterson in 1962 (1). In addition to the programs presented in this issue, the following program was previously covered in *Radiological Health Data and Reports*.

<u>Network</u>	<u>Period reported</u>	<u>Last presented</u>
HASL Fallout Network	July-December 1965	September 1966

1. Radiation Surveillance Network November 1966

*National Center for Radiological Health
Public Health Service*

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples at 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Md., for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta radioactivity made by the station operators prior to submission of the samples for laboratory analysis. When high radioactivity levels in air are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (2). A detailed description of the sampling and

Table 1. Gross beta radioactivity in surface air and precipitation, November 1966

Station location		Number of samples		Air surveillance (gross beta radioactivity, pCi/m ³)			Last profile in R/D & R	Precipitation	
		Air	Pptn	Maximum	Minimum	Average *		Total depth (mm)	Total disposition (nCi/m ²)
Ala:	Montgomery	30	5	8.46	<0.10	<0.75	Nov 66	88	<18
Alaska:	Adak	30		0.20	<0.10	<0.11	June 66	(*) 11	<2
	Anchorage	16	3	0.49	<0.10	<0.14	Dec 66	(*)	
	Attu Island	30		0.14	<0.10	<0.10	July 66	(*) 52	<12
	Fairbanks	20	12	0.14	<0.10	<0.10	Jan 67	165	<35
	Juneau	19	9	0.47	<0.10	<0.13	Feb 67	(*)	
	Kodiak	8		0.83	<0.10	<0.18	Mar 67	(*)	
	Nome	10		0.10	<0.10	<0.10	Sept 66	(*)	
	Pt. Barrow	25		0.33	<0.10	<0.12	Aug 66	(*)	
	St. Paul Island	(b)					Oct 66	(*)	
Ariz:	Phoenix	30		0.50	<0.10	<0.20	Feb 67	(*) 83	<17
Ark:	Little Rock	25	4	13.62	<0.10	<0.93	Dec 66	131	<39
Calif:	Berkeley	19	8	4.54	<0.10	<0.65	Mar 67	113	<23
	Los Angeles	17	3	2.23	<0.10	<0.44	Sept 66	(*)	
	San Diego	13		<0.10	<0.10	<0.10	Feb 67	(*) 7	<1
C. Z:	Ancon	13	2	4.00	<0.10	<0.54	Mar 67	73	<17
Colo:	Denver	30	14	0.79	<0.10	<0.27	Jan 67	(*)	
Conn:	Hartford	20		0.71	<0.10	<0.22	Nov 66	(*) 27	<5
Del:	Dover	27	8	1.25	<0.10	<0.26	Aug 66	7	<2
D.C.:	Washington	29	4	5.09	<0.10	<0.51	Dec 66	60	<13
Fla:	Jacksonville	29	8	11.81	<0.10	<1.02	Jan 67	(*)	
	Miami	29					Oct 66	(*)	
Ga:	Atlanta	14		4.18	<0.10	<0.67	Nov 66	(*)	
Hawaii:	Agana	30	8	6.20	<0.10	<0.11	Nov 66	200	<40
	Honolulu	29	7	3.29	<0.10	<0.25	July 66	131	<33
Ia:	Boise	29	6	13.63	<0.10	<0.96	July 66	95	<19
Ill:	Springfield	30	10	10.84	<0.10	<0.84	Aug 66	101	<28
Ind:	Indianapolis	30	3	9.31	<0.10	<0.74	Oct 66	32	<6
Iowa:	Iowa City	29	3	5.55	<0.10	<0.52	Feb 67	6	13
Kans:	Topeka	30	3	7.02	<0.10	<0.56	Dec 66	68	<14
Ky:	Frankfort	26	9	9.86	<0.10	<0.73	Aug 66	12	<2
La:	New Orleans	30	7	5.88	<0.10	<0.82	Aug 66	163	<33
Maine:	Augusta	29	11	0.63	<0.10	<0.25	Sept 66	(*)	
	Presque Isle	19		0.55	<0.10	<0.20	Feb 67	(*) 30	<6
Md:	Baltimore	19	3	1.34	<0.10	<0.27	Jan 67	(*)	
	Rockville	18		0.96	<0.10	<0.23	July 66	(*) 120	<26
Mass:	Lawrence	29	13	1.13	<0.10	<0.31	Nov 66	105	<21
	Winchester	27	16	1.31	<0.10	<0.36	Mar 67	58	<16
Mich:	Lansing	30	7	0.87	<0.10	<0.64	July 66	5	<1
Minn:	Minneapolis	20	3	0.21	<0.10	<0.13	Nov 66	58	<12
Miss:	Jackson	29	4	11.97	<0.10	<1.07	Sept 66	43	<17
Mo:	Jefferson City	30	5	11.27	<0.10	<0.97	Oct 66	27	<6
Mont:	Helena	27	6	5.90	<0.10	<0.69	June 66	(*)	
Nebr:	Lincoln	20		2.52	<0.10	<0.24	Oct 66	(*)	
Nev:	Las Vegas	17		2.11	<0.10	<0.38	Jan 67	(*)	
N.H.:	Concord	17		0.97	<0.10	<0.30	Aug 66	(*)	
N.J.:	Trenton	30	4	0.95	<0.10	<0.21	Sept 66	10	<2
N. Mex:	Santa Fe	25	2	0.52	<0.10	<0.20	June 66	9	<2
N.Y.:	Albany	19	11	1.22	<0.10	<0.21	Oct 66	(*) 55	<11
	Buffalo	21		3.52	<0.10	<0.43	Feb 67	(*)	
	New York	29		0.66	<0.10	<0.20	Mar 67	(*) 22	<5
N.C.:	Gastonia	28	5	1.85	<0.10	<0.36	Feb 67	7	5
N. Dak:	Bismarck	30	2	0.87	<0.10	<0.17	Aug 66	(*)	
Ohio:	Cincinnati	12		11.35	<0.10	<1.16	Nov 66	(*)	
	Columbus	29	9	11.11	<0.10	<0.77	Sept 66	(*) 98	<23
	Painesville	30	13	6.92	<0.10	<0.57	Jan 67	138	<31
Okla:	Oklahoma City	29	1	6.22	<0.10	<0.56	July 66	(*) 11	<2
	Ponca City	30		3.16	<0.10	<0.26	Jan 67	(*)	
Ore:	Portland	29	16	2.83	<0.10	<0.23	Oct 66	99	<22
Pa:	Harrisburg	29	3	0.50	<0.10	<0.18	Oct 66	56	<11
P.R.:	San Juan	26	7	0.53	<0.10	<0.14	Sept 66	159	<32
R.I.:	Providence	29	9	0.74	<0.10	<0.22	July 66	110	<25
S.C.:	Columbia	29	6	1.50	<0.10	<0.34	Mar 67	26	<5
S. Dak:	Pierre	30	1	2.73	<0.10	<0.33	Feb 67	7	<1
Tenn:	Nashville	29	9	9.24	<0.10	<0.65	July 66	67	<14
Tex:	Austin	30	3	11.31	<0.10	<1.08	Nov 66	2	<1
	El Paso	30	1	0.61	<0.10	<0.17	Aug 66	1	<1
	Salt Lake City	30	6	28.71	<0.10	<2.46	Sept 66	24	<5
Utah:	Barre	30	11	1.12	<0.10	<0.30	Dec 66	40	<9
Vt:	Richmond	30	6	0.85	<0.10	<0.25	Dec 66	111	<22
Va:	Seattle	29	17	0.39	<0.10	<0.13	Dec 66	118	<27
Wash:	Seattle	30	3	2.03	<0.10	<0.24	Nov 66	31	<6
	Spokane	30	11	3.14	<0.10	<0.38	Mar 67	59	<13
W. Va:	Charleston	29	3	4.87	<0.10	<0.26	Dec 66	27	<6
Wis:	Madison	29	3	7.74	<0.10	<0.93	Jan 67	7	<10
Wyo:	Cheyenne	29							
Network summary		1,875	363	28.71	<0.10	<0.44		62	<14

* The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If 10 percent or more samples from a station contain <0.10 pCi/m³, a less-than sign is placed before the average.
 b No precipitation sample collected
 c No report received



Figure 1. Radiation Surveillance Network sampling stations

analytical procedures was presented in the November 1966 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air and deposition by precipitation during November 1966. Time profiles of gross beta radioactivity in air for eight RSN stations are shown in figure 2. Gross beta radioactivity on air samples collected by most RSN stations increased sharply and remained elevated for several days, beginning about a week to 10 days after the October 27, 1966, nuclear detonations in mainland China and the USSR. Levels reached were comparable to those found after the May 9, 1966, Chinese mainland test. A summary of RSN findings is shown in table 2. The most active sample received was collected on November 5, 1966, at Salt Lake City, Utah, and extrapolated to 28.71 pCi/m³ at the time of collection. Precipitation radioactivity levels were slightly elevated dur-

ing November and fresh fission products were identified in the samples in table 3.

Table 2. Summary of fresh fission product activity observed in RSN air findings

Distribution of activities	Number of samples
1. Fresh fission products, contents confirmed by gamma-ray spectrometry	214
2. Less than 1.0 pCi/m ³	97
3. 1.0 to 9.9 pCi/m ³	104
4. 10.0 to 19.9 pCi/m ³	11
5. 20.0 pCi/m ³ or greater	2
6. Total number of samples collected	1,875

Table 3. Fresh fission product activity observed in precipitation samples

Location	Date 1966	Concentration (pCi/liter)	Deposition (nCi/m ²)
Wyo: Cheyenne	Nov. 4	2,500	8.7
Kans: Topeka	Nov. 5	3,000	11.9
N. Dak: Bismarck	Nov. 7	1,200	4.3
Ind: Indianapolis	Nov. 7	900	2.0

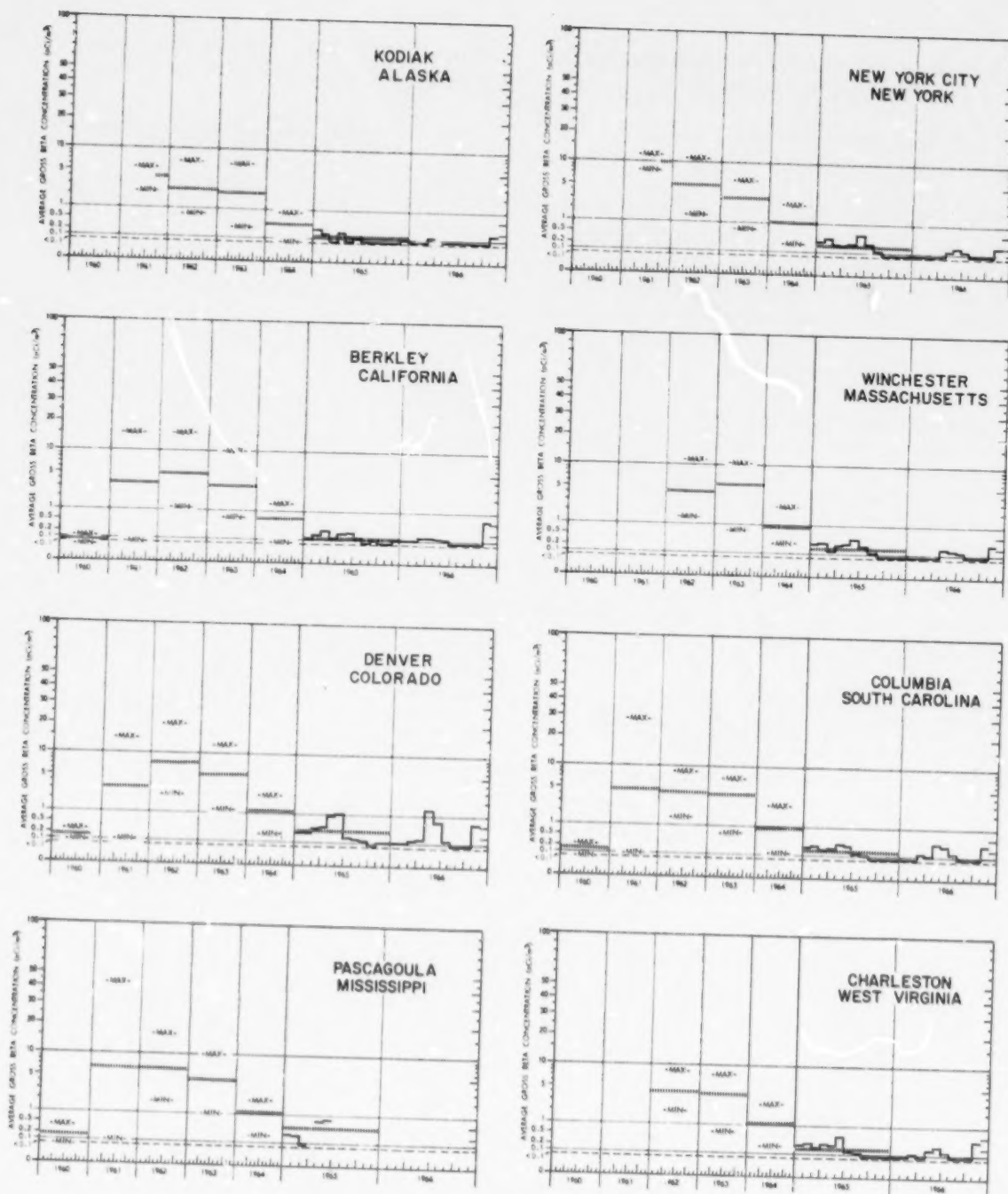


Figure 2. Monthly and yearly profiles of beta radioactivity in air—
Radiation Surveillance Network, 1960-November 1966

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2. Canadian Air and Precipitation Monitoring Program, November 1966¹

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport (figure 3). Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (3-7).

A summary of the sampling procedures and methods of analysis was presented in the November 1966 issue of *Radiological Health Data and Reports*.

¹ Prepared from information and data in the December 1966 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for November 1966 are presented in table 4.

Table 4. Canadian gross beta activity in surface air and precipitation, November 1966

Station	Number of samples	Air surveillance activity (pCi/m ³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m ²)
Calgary	30	11.5	0.1	1.0	45	1.5
Coral Harbour	29	0.4	0.0	0.1	47	0.5
Edmonton	30	7.5	0.0	0.5	69	1.8
Ft. Churchill	30	0.9	0.0	0.2	12	0.5
Ft. William	30	0.5	0.0	0.2	21	0.8
Fredericton	30	1.0	0.0	0.2	18	1.7
Goose Bay	29	0.3	0.0	0.1	17	1.0
Halifax	30	3.6	0.0	0.4	65	4.9
Inuvik	30	1.0	0.0	0.2	37	0.3
Montreal	14	5.5	0.0	0.8	58	5.4
Moosonee	30	1.3	0.0	0.2	NS	NS
Ottawa	30	4.8	0.0	0.8	42	4.4
Quebec	30	1.4	0.0	0.3	16	2.7
Resolute	30	2.9	0.1	0.4	34	0.8
St. John's, Nfld.	29	8.0	0.0	0.6	T	0.2
	30	4.3	0.0	0.3	15	1.8
Saskatoon	30	4.6	0.1	0.5	75	1.6
Sault Ste. Marie	30	1.6	0.0	0.3	27	4.2
Toronto	30	7.0	0.0	0.9	54	7.1
Vancouver	30	0.8	0.0	0.2	28	4.8
Whitehorse	30	0.4	0.0	0.2	31	0.7
Windsor	30	17.0	0.0	1.2	44	5.1
Winnipeg	30	2.0	0.0	0.2	25	0.7
Yellowknife	30	0.6	0.0	0.2	20	0.4
Network summary		3.7	0.0	0.4	36	2.3

NS, no sample
T, trace precipitation



Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program November 1966

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new radiation surveillance network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F., Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the

University of Mérida, the Instituto de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day, using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of eight samples per month were needed to get a reliable average activity at each station (1).

The maximum, minimum, and average fission product beta concentrations in surface air during November 1966 are presented in table 5.

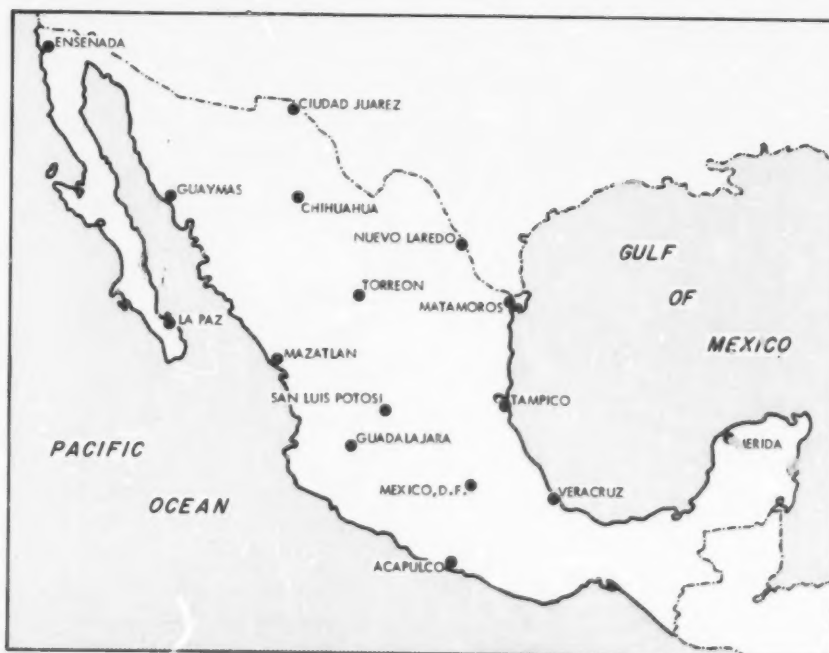


Figure 4. Mexican air sampling station locations

Table 5. Mexican gross beta radioactivity of airborne particulates, November 1966

Station	Number of samples	Gross beta radioactivity, pCi/m ³		
		Maximum	Minimum	Average
Acapulco	20	0.1	<0.1	0.1
Chihuahua	15	0.2	<0.1	0.1
Ciudad Juárez	7	0.2	<0.1	0.1
Ensenada	13	0.2	<0.1	0.1
Guadalajara	NS			
Guaymas	NS			
La Paz	8	0.1	<0.1	0.1
Matamoros	NS			
Mazatlán	11	0.2	0.1	0.1
Mérida	6	0.2	0.1	0.1
México, D.F.	11	0.1	<0.1	0.1
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	16	1.5	<0.1	0.2
Torreón	11	0.2	<0.1	0.1
Veracruz	7	0.4	0.1	0.1

NS, no sample collected, station temporarily shutdown

4. Pan American Air Sampling Program November 1966

*Pan American Health Organization and
U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the National Center for Radiological Health,



Figure 5. Pan American Air Sampling Program stations

PHS, and are identical with those employed for the Radiation Surveillance Network. The air sampling station positions are shown in figure 5.

The November 1966 air monitoring results from the participating countries are given in

Table 6. PAHO gross beta radioactivity in surface air, November 1966

Station location	Number of samples	Gross beta radioactivity, pCi/m ³		
		Maximum	Minimum	Average *
Argentina: Buenos Aires.....	16	1.49	<0.10	0.50
Chile: Santiago.....	20	1.41	0.11	0.60
Colombia: Bogota.....	19	1.05	<0.10	<0.18
Ecuador: Guayaquil.....	26	5.86	0.25	1.37
Jamaica: Kingston.....	21	1.29	<0.10	<0.17
Peru: Lima.....	2	1.99	1.11	1.55
Venezuela: Caracas.....	20	0.45	<0.10	<0.17
West Indies: Trinidad.....	18	0.30	<0.10	<0.12
Pan American summary.....	151	5.86	<0.10	<0.58

* The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If 10 percent or more of the samples from a station contain <0.10 pCi/m³, a less-than sign is placed before the average.

table 6. Levels were considerably lower than October levels. During November, fresh fission products were identified in the samples in table 7.

Table 7. Fresh fission product activity observed in PAHO air samples, November 1966

Location	Dates November 1966	Most active sample at time of collection (pCi/m ³)	Date of most active sample
Peru: Lima.....	8, 9 *	1.99	Nov. 8
Chile: Santiago.....	1, 2, 4-14, 16-30 ^b	1.41	Nov. 5
Venezuela: Caracas.....	1-4, 11 *	0.45	Nov. 11
Argentina: Buenos Aires.....	2-12, 15-17 ^c	1.49	Nov. 3
Jamaica: Kingston.....	10-12	1.29	Nov. 10
West Indies: Trinidad.....	10 *	0.30	Nov. 10
Colombia: Bogota.....	2 ^d	1.05	Nov. 2
Ecuador: Guayaquil.....	1-6, 8-19, 23-30 *	5.86	Nov. 2

* No sample received for Nov. 1-7, 10-30

^b No sample received for Nov. 3.

^c No sample received for Nov. 22, 23.

^d No sample received for Nov. 22-30.

^e No sample received for Nov. 18-21.

^f No sample received for Nov. 9-12, 15, 30.

^g No sample received for Nov. 7, 20-22.

5. Fallout in the United States and other areas January-June 1966^a

*Health and Safety Laboratory
U.S. Atomic Energy Commission*

Monthly fallout deposition rates for strontium-90 are determined by the Health and Safety Laboratory (HASL) for 49 sites in the United States and 107 locations in other countries. HASL data from all of the active U.S. stations and other selected points in the Western Hemisphere (figure 6) covering the period from January through June 1966 are summarized in tables 8 and 9. All the stations of the 80th Meridian Network are represented.

^a The data in this article were taken from Fallout Program Quarterly Summary Report, HASL 174:A-1 to A-169; B-1 to B-22.

Methods of collection

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout are collected for a period of 1 month in a stainless-steel pot with an exposed area of 0.076 m². At the end of the collection period the contents are transferred by careful scrubbing with a rubber spatula, to a polyethylene sample bottle, which is then shipped to the laboratory for analysis.

The second method involves the use of a polyethylene funnel, with an exposed area of 0.072 m², attached to an ion exchange column. After a 1-month collection, the inside of the funnel is wiped with a tissue and the tissue is inserted in the end of the column, which is then sealed and sent to HASL for analysis. At the 95-percent confidence level there is no significant difference in the strontium-90 measurements obtained from samples collected by the two methods (1).



Figure 6. HASL fallout sampling stations in the Western Hemisphere

Table 8. Strontium-90 fallout in the United States, HASL, January-June 1966

Sampling location			Type of collection	Fallout deposition, nCi m ⁻²					
				Jan	Feb	Mar	Apr	May	June
Ala	Birmingham		pot	0.23	0.47	0.35	0.57	0.18	0.24
Alaska	Anchorage		column	0.04	0.05	0.01	0.09	0.12	0.07
	Barrow		column	0.05	0.08	0.01	0.02	0.01	0.05
	Cold Bay		column	NS	NS	NS	NS	NS	NS
	Fairbanks		column	0.03	T	0.03	T	0.13	0.12
	Juneau		column	NS	0.49	0.39	0.12	NS	0.39
	Nome		column	0.02	T	NS	NS	0.04	NS
Calif	W. Los Angeles		pot	0.16	0.05	0.14	0.03	NS	0.06
	San Francisco		column	T	T	0.07	0.07	0.06	0.07
Colo	Denver		column	T	0.24	0.10	0.24	0.05	NS
Fla	Coral Gables		pot	0.06	NS	0.11	0.08	0.72	NS
	Miami		column	0.28	0.00	0.15	0.17	0.26	0.69
Hawai	Hilo		column	0.11	0.45	0.46	0.47	0.32	0.54
	Honolulu		pot	0.05	0.36	0.24	0.08	0.13	0.11
	Lihoe		column	0.14	0.56	0.09	0.31	0.09	0.07
	Mauna Loa		column	T	0.25	0.04	0.04	T	0.01
Ill	Argonne		pot	0.02	0.12	NS	0.44	0.24	0.19
La	New Orleans		column	0.26	0.37	0.23	0.25	0.16	0.04
Miss	International Falls		column	0.03	0.11	0.24	0.19	0.15	0.25
Mont	Columbia		column	0.03	T	0.18	0.47	0.32	0.40
N.J.	Westwood		column	T	0.07	T	0.16	0.17	0.22
			pot	0.14	NS	NS	NS	NS	NS
N.Y.	New York		pot	0.12	0.17	0.28	0.45	0.56	0.16
N. Dak	Williston		column	0.02	0.01	0.29	0.10	0.24	0.16
Ohio	Wooster		pot	0.15	0.07	0.31	0.29	0.30	0.42
Okl	Tulsa		pot	NS	0.22	0.10	0.34	0.55	0.20
Ore	Medford		column	0.19	0.06	0.20	0.05	0.10	0.05
S.C.	Columbia		column	T	0.23	0.11	0.22	0.42	0.17
S. Dak	Vermillion		pot	0.03	0.04	0.10	0.39	0.50	0.59
Tex.	Dallas		column	0.13	0.12	0.22	0.46	0.13	0.12
	El Paso		column	0.16	0.41	0.04	0.26	0.11	0.08
	Houston		column	0.09	0.26	0.16	0.39	0.12	0.37
Utah	Salt Lake City		pot	0.11	0.22	0.16	0.39	0.16	0.11
Va	Sterling		column	0.08	0.18	0.18	0.29	0.25	0.06
Wash	Seattle		pot	0.22	0.24	0.46	0.28	0.38	0.15
	Seattle		pot	0.10	0.20	0.32	0.44	0.24	0.13
	Tatoosh Island		column	NS	T	0.99	0.60	0.02	0.21
Wis	Green Bay		column	0.01	0.14	0.45	0.21	0.18	0.11

NS, no sample reported
T, zero or trace

Other radionuclides

Laboratories at Westwood, N.J., New York, N.Y., and Seattle, Wash., have analyzed monthly precipitation samples for various radionuclides. The amount of precipitation and the monthly deposition rates at each station for iron-55, strontium-90, cerium-144, plutonium-238, plutonium-239, and plutonium-240 are presented in table 10.

REFERENCES

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Table 9. Strontium-90 fallout in North and South America, HASL, January-June 1966

Sampling location		Type of collection	Fallout deposition, nCi/m ²					
			Jan	Feb	Mar	Apr	May	June
Argentina:	Buenos Aires	column	0.22	0.14	0.13	0.07	0.05	0.05
	Formosa	column	0.06	0.25	0.10	0.05	0.06	0.02
	Mdargue	column	NS	0.24	0.11	0.04	0.01	0.06
Bahamas:	Himn	column	NS	NS	NS	NS	NS	NS
Bermuda:	Kindley AFB	column	0.06	0.38	0.42	0.21	0.10	0.08
Bolivia:	Chacaltaya	column	0.07	0.01	T	0.02	NS	NS
	La Paz (city)	column	0.07	T	0.03	0.02	NS	NS
	La Paz (Ovejuyo)	column	0.10	0.03	0.02	0.02	NS	NS
Brazil:	Belem	column	T	0.16	0.02	0.06	0.05	0.03
	Brasilia	pot	T	T	NS	NS	NS	NS
	Rio de Janeiro	pot	NS	NS	NS	NS	NS	NS
	Sao Paulo	pot	NS	NS	NS	NS	NS	NS
	Trindade Island	pot	0.08	* 0.06	* 0.07	0.06	NS	NS
	Sao Jose Dos Campos	column	0.06	0.19	0.26	0.10	NS	NS
	Sao Leopoldo	pot	0.02	T	NS	NS	NS	NS
	Trindade Island	pot	0.16	0.14	0.13	0.06	NS	NS
	Trindade Island	column	0.03	0.05	T	0.04	0.04	0.04
Canada:	Moosonee	column	0.20	0.05	0.10	0.06	0.10	0.02
Canal Zone:	Newfoundland	column	0.01	T	0.05	NS	NS	NS
Chile:	Miraflores	column	0.06	T	0.04	0.27	0.09	T
	Antofagasta	column	0.02	T	0.01	0.01	0.05	T
	I. Alejandro Selkirk	column	0.06	T	0.10	0.11	NS	NS
	Easter Island	column	0.06	0.06	0.06	0.03	0.05	0.04
	Puerto Montt	column	0.06	0.11	0.14	0.09	0.20	0.10
	Punta Arenas	column	T	0.05	0.12	0.05	0.03	0.02
	Santiago	pot	T	T	T	0.02	T	NS
	Santiago	column	0.16	0.21	T	NS	0.02	0.06
Colombia:	Bogota	pot	T	0.01	NS	NS	NS	NS
Costa Rica:	Turrialba	column	T	0.10	0.01	0.07	0.07	0.04
Ecuador:	Guayaquil	column	0.06	0.03	T	0.02	0.03	T
	Quito	column	T	0.01	0.02	0.02	0.07	* 0.07
Greenland:	Thule	column	* 0.01	* 0.01	* 0.02	* 0.02	* 0.02	* 0.07
Iceland:	Keflavik	column	0.13	0.25	0.18	0.22	0.26	0.07
Mexico:	Mexico City	column	0.07	0.16	0.18	T	0.07	T
Peru:	Lima	column	0.03	T	0.01	NS	NS	0.02
Puerto Rico:	San Juan	column	0.06	0.01	T	0.02	T	T
Venezuela:	Caracas (site 1)	column	0.06	0.28	0.15	0.18	0.17	0.07
	Caracas (site 2)	column	0.15	T	0.02	0.08	T	0.05
		column	T	NS	NS	T	0.03	0.03

* Indicates proportioned from originally consolidated data
 NS, no sample reported
 T, zero or trace

Table 10. Radiochemical analyses of precipitation samples at 3 U.S. sites, HASL January-June 1966

	Jan	Feb	Mar	Apr	May	June
Precipitation (cm)						
N.J.: Westwood	5.26	9.65	3.38	6.98	10.29	2.11
N.Y.: New York	6.68	12.69	2.39	6.83	10.82	2.97
Wash: Seattle	12.45	6.25	12.06	5.13	3.40	1.90
Iron-55 (nCi/m ²)						
N.J.: Westwood	1.51	1.36	2.95	2.28	4.16	0.89
Wash: Seattle	0.02	0.16	5.79	6.14	3.56	1.42
Strontium-90 (nCi/m ²)						
N.J.: Westwood	0.14	0.11	0.40	0.43	0.69	0.19
N.Y.: New York	0.12	0.17	0.28	0.45	0.56	0.16
Wash: Seattle	0.22	0.24	0.46	0.28	0.33	0.15
Cerium-144 (nCi/m ²)						
N.J.: Westwood	0.34	0.36	0.69	0.59	1.26	0.40
Wash: Seattle	0.42	0.43	0.81	0.58	0.60	0.29
Plutonium-238 (nCi/m ²)						
N.Y.: New York	0.00012	0.00030	0.00042	0.00018	0.00057	NS
Wash: Seattle	<0.00023	<0.00022	0.00077	* 0.018	* 0.0038	* 0.012
Plutonium-239-240 (nCi/m ²)						
N.Y.: New York	0.0035	0.0032	0.0020	0.0046	0.0045	NS
Wash: Seattle	0.0027	0.0013	0.0137	0.0074	0.0086	0.0053

* Data suspect
 NS, no sample reported

Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections.

Included are such data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

STRONTIUM-90 IN HUMAN BONE, APRIL-JUNE 1966¹

*National Center for Radiological Health
Public Health Service*

To obtain data on the concentration of strontium-90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. The target population includes children and young adults up to 25 years of age. Since strontium-90 in measurable amounts has been present in the global environment for more than a decade and major calcium accretion ceases by age 17 or 18, persons over 25 years old are of limited interest in the program. This has been confirmed by analyses of selected samples of people in older age groups, the results having shown their bone strontium-90 content to be low and age-independent (1).

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is

readily available from older children, but it presents some difficulties in cases of infants and children under 5 years of age.

Most specimens received to date have been vertebrae and ribs. Efforts to collect long bones for comparison of results with British data have not been successful.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory of the National Center for Radiological Health, at Winchester, Mass. Procedures for sample collection and preparation are explained elsewhere (2). Strontium-90 is measured by TBP extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium-90 content is then calculated from the yttrium-90 radioactivity (3). For the purpose of maintaining analytical reproducibility, "blind" duplicate analyses are performed on 10 to 20 percent of the samples. To further check and maintain analytical accuracy, synthetic "bone ash" samples (calcium phosphate spiked with strontium-90) are analyzed periodically and cross-check analyses are carried out quarterly with the Health and

¹ Period during which death or surgical procedure occurred.

Safety Laboratory of the AEC, which performs similar analyses.

The analytical results for strontium-90 in individual bones from persons dying during the second quarter (April-June) of 1966, along with other pertinent data are presented in table 1 in order of increasing age within each geographic sampling region. These regions are indicated in figure 1. Reported values are given in picocuries of strontium-90 per gram of ash (the primary determination), per gram of calcium (for comparison with other data and for purposes of model development), and per gram of bone (as a rough indication of dose). Two standard deviation counting errors are reported for the ash concentration.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (2-4).

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
Deaths through 1964	April 1966
First quarter 1965	June 1966
Second quarter 1965	September 1966
Third quarter 1965	October 1966
Fourth quarter 1965	December 1966
First quarter 1966	February 1967

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Figure 1. Geographical regions for human bone sampling

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Table 1. Strontium-90 in human bone, deaths and surgical procedures during April-June 1966

Sampling region and state of residence	Sex	Bone type *	Age at death ^b (years)	Cause of death	Strontium-90, pCi/g of		
					Ash $\pm 2\sigma$ error	Calcium	Bone
NORTHEAST:							
N.Y.	M	V	1	Ependymoma	1.88 $\pm$ 0.28	5.50	0.12
N.Y.	M	V	1	Myeloblastic leukemia	1.05 $\pm$ 0.14	3.02	0.08
N.Y.	F	V	2	Sarcoma of buttock	1.03 $\pm$ 0.15	2.84	0.09
Mass.	M	V	2	Acute leukemia	1.73 $\pm$ 0.17	5.04	0.13
N.Y.	F	V	4	Respiratory obstruction	1.39 $\pm$ 0.16	3.98	0.11
Pa.	M	V	4	Multiple injuries	0.85 $\pm$ 0.12	2.43	0.07
N.Y.	M	V	5	Lymphoblastic leukemia	0.49 $\pm$ 0.05	1.30	0.06
N.Y.	F	V	6	Cerebral hemorrhage	1.05 $\pm$ 0.13	2.92	0.10
N.Y.	F	V	6	Head injuries	1.37 $\pm$ 0.13	3.79	0.13
R.I.	M	V	6	Tetralogy of Fallot	1.04 $\pm$ 0.08	3.00	0.11
Mass.	M	V	7	Cystic fibrosis	1.47 $\pm$ 0.15	4.21	0.12
N.H.	M	V	8	Multiple injuries	0.82 $\pm$ 0.11	2.22	0.09
N.Y.	M	V	8	Cerebral contusion	1.00 $\pm$ 0.09	2.78	0.10
Mass.	F	V	9	Congenital heart disease	0.65 $\pm$ 0.06	1.82	0.06
N.H.	M	V	9	Acute leukemia	1.19 $\pm$ 0.10	3.28	0.13
N.Y.	M	V	9	Head injuries	0.88 $\pm$ 0.09	2.39	0.08
Mass.	M	V	9	Hodgkins disease	1.37 $\pm$ 0.11	3.64	0.14
N.Y.	F	V	11	Acute leukemia	0.50 $\pm$ 0.07	1.32	0.05
(c)	M	V	11	Agammaglobulinemia	0.47 $\pm$ 0.07	1.31	0.05
N.Y.	M	V	12	Acute leukemia	0.76 $\pm$ 0.09	2.07	0.08
Mass.	M	V	13	Tetralogy of Fallot	1.05 $\pm$ 0.11	2.89	0.09
Maine.	F	V	14	Hemangioma	0.90 $\pm$ 0.10	2.46	0.10
Mass.	M	V	14	Hodgkin's disease	1.28 $\pm$ 0.08	3.40	0.17
N.Y.	M	V	14	Primary astrocytoma	1.09 $\pm$ 0.09	2.92	0.12
Mass.	F	V	15	Intracranial tumor	1.03 $\pm$ 0.09	2.66	0.13
Mass.	M	V	15	Head injuries	1.12 $\pm$ 0.08	2.96	0.15
N.Y.	M	V	15	Cerebral thrombosis	1.51 $\pm$ 0.10	4.25	0.20
Mass.	M	V	16	Acute leukemia	1.21 $\pm$ 0.15	3.17	0.15
N.H.	M	V	16	Head injuries	1.02 $\pm$ 0.09	2.73	0.14
N.Y.	M	V	17	Acute leukemia	0.86 $\pm$ 0.08	2.24	0.09
R.I.	M	V	17	Cystic fibrosis	0.73 $\pm$ 0.07	1.92	0.08
Mass.	F	V	18	Glioblastoma	0.55 $\pm$ 0.05	1.50	0.05
N.H.	M	V	18	Cerebral laceration	0.93 $\pm$ 0.07	2.32	0.13
Pa.	M	V	18	Thermal burns	0.72 $\pm$ 0.07	1.85	0.10
Conn.	M	V	20	Rupture of aorta	0.68 $\pm$ 0.06	1.76	0.10
N.Y.	F	V	21	Brain stem contusions	0.61 $\pm$ 0.06	1.59	0.10
Mass.	F	V	22	Pancreatic carcinoma	0.65 $\pm$ 0.06	1.67	0.07
N.Y.	M	V	22	Hodgkin's disease	0.81 $\pm$ 0.10	2.25	0.06
Pa.	F	V	24	Multiple injuries	0.53 $\pm$ 0.07	1.37	0.06
N.Y.	M	V	24	Carcinoma of nasopharynx	0.63 $\pm$ 0.10	1.70	0.07
SOUTHEAST:							
Tenn.	M	V	6	Ingestion of gasoline	1.14 $\pm$ 0.18	3.14	0.11
S.C.	M	V	14	Cystic fibrosis	1.13 $\pm$ 0.07	3.28	0.22
CENTRAL:							
Wis.	M	V	0 (5 mo)	Viral encephalitis	1.56 $\pm$ 0.23	4.21	0.14
Ohio.	F	V	1	Salicylate poisoning	1.52 $\pm$ 0.16	4.16	0.14
Wis.	M	V	1	Cystic fibrosis	1.04 $\pm$ 0.18	3.00	0.08
(c)	M	V	1	(c)	1.30 $\pm$ 0.16	3.56	0.12
Ohio.	M	V	1	Acute meningococemia	1.07 $\pm$ 0.17	2.99	0.10
Ohio.	F	V	2	Congenital heart disease	2.39 $\pm$ 0.22	6.65	0.23
Ohio.	M	V	2	Hirschsprung's disease	0.70 $\pm$ 0.11	1.90	0.06
Ohio.	M	V	2	Gunshot wound of head	1.43 $\pm$ 0.12	3.83	0.23
(c)	M	V	4	(c)	0.84 $\pm$ 0.10	2.48	0.08
(c)	M	V	4	(c)	1.22 $\pm$ 0.12	3.37	0.11
Minn.	F	V	5	Thermal burns	0.87 $\pm$ 0.15	2.48	0.06
Iowa.	F	V	5	Thermal burns	1.24 $\pm$ 0.17	3.60	0.09
Wis.	M	V	5	Drowning	0.67 $\pm$ 0.11	1.96	0.05
Ohio.	F	V	6	Acute enteritis	0.84 $\pm$ 0.11	2.29	0.08
Minn.	F	V	6	Familial nephrosis	2.59 $\pm$ 0.24	8.10	0.17
(c)	F	V	7	(c)	0.93 $\pm$ 0.08	2.63	0.09
Wis.	M	V	9	Lymphosarcoma	1.06 $\pm$ 0.09	2.87	0.12
Wis.	M	V	9	Cerebral hemorrhage	0.72 $\pm$ 0.07	2.01	0.07
Ohio.	F	V	10	Chronic hepatitis	0.49 $\pm$ 0.05	2.13	0.07
Wis.	F	V	11	Lymphocytic leukemia	0.63 $\pm$ 0.06	1.75	0.06
Minn.	F	V	11	Multiple injuries	0.79 $\pm$ 0.07	2.15	0.09
Ohio.	M	V	13	Rheumatoid arthritis	0.92 $\pm$ 0.10	2.61	0.07
Minn.	F	V	15	Leukemia	0.72 $\pm$ 0.11	1.97	0.07
Minn.	M	V	15	Bicycle accident	1.28 $\pm$ 0.08	3.35	0.18
Ohio.	M	V	18	Multiple fractures	0.94 $\pm$ 0.08	2.41	0.19
Ohio.	M	V	18	Laceration of lung	1.06 $\pm$ 0.08	2.78	0.21
Ohio.	M	V	18	Fractures of skull	0.66 $\pm$ 0.09	1.76	0.14
Ohio.	M	V	18	Injuries of brain	0.94 $\pm$ 0.07	2.43	0.19
Mich.	M	V	22	Multiple injuries	0.58 $\pm$ 0.08	1.56	0.08
Ohio.	M	V	22	Cerebral contusions	0.66 $\pm$ 0.06	1.74	0.09
Ohio.	F	V	23	Intracranial hemorrhage	1.02 $\pm$ 0.09	2.66	0.19
Ohio.	M	V	23	Shotgun wound of head	0.73 $\pm$ 0.06	1.89	0.13
Ohio.	M	V	25	Gunshot wounds of body	0.56 $\pm$ 0.06	1.44	0.12

See footnotes at end of table.

Table 2. Strontium-90 in human bone, deaths and surgical procedures during April-June 1966—Continued

Sampling region and state of residence	Sex	Bone type ^a	Age at death ^b (years)	Cause of death	Strontium-90, pCi/g of:		
					Ash $\pm 2\sigma$ error	Calcium	Bone
DELTA:							
La.....	F	V	0(4 mo.)	Congenital heart disease.....	1.84 ± 0.19	5.44	0.14
La.....	F	V	9	Lobar pneumonia.....	1.09 ± 0.10	3.04	0.11
La.....	M	V, R	13	Glomerulonephritis.....	1.16 ± 0.12	3.39	0.12
La.....	F	V	19	Medulloblastoma.....	0.66 ± 0.07	1.72	0.09
La.....	M	V	24	Diabetes mellitus.....	0.56 ± 0.06	1.40	0.10
NORTHWEST:							
Alaska.....	F	R	13	(d).....	1.33 ± 0.16	3.32	0.45
Alaska.....	M	R	25	(d).....	0.96 ± 0.16	2.45	0.37
SOUTHWEST:							
(c).....	F	S	1	(e).....	0.41 ± 0.10	1.45	0.10
Tex.....	M	V	6	Acute leukemia.....	0.78 ± 0.10	2.23	0.06
Tex.....	F	V	8	Perforated bowel.....	0.51 ± 0.09	1.40	0.04
Tex.....	F	V	10	Acute leukemia.....	0.64 ± 0.11	1.78	0.07
Utah.....	M	V	11	Inhalation of glue fumes.....	0.58 ± 0.09	1.57	0.06
Tex.....	F	V	18	(e).....	0.67 ± 0.07	1.91	0.10
(e).....	F	V	19	Hypovolemic shock.....	0.72 ± 0.08	1.86	0.09
Colo.....	M	V	23	Traumatic quadriplegia.....	0.50 ± 0.05	1.32	0.06
Utah.....	M	V	25	Anaphylactic reaction.....	0.57 ± 0.08	1.48	0.08

^a Type of bone: V, vertebrae; S, sternum; R, rib.
^b Age given as of last birthday prior to death.
^c Information not yet available.
^d Sample obtained from surgical procedure.

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."¹

Summaries of data from the environmental radioactivity monitoring reports follow for the Argonne National Laboratory, Atomic International, Feed Materials Production Facilities and the National Reactor Testing Station.

¹ Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

1. Argonne National Laboratory January-June 1966²

University of Chicago
Lemont, Illinois

The radioactivity of the environment is determined on a continuing basis by measuring the radioactivity in naturally occurring materials collected both on and off the Argonne National Laboratory site. Since radioactivity is usually spread by air and water, the environmental monitoring program at Argonne has concentrated on these materials. The sampling locations discussed are shown in figures 1 and 2.

² Summarized from "Environmental Radioactivity at Argonne National Laboratory, January-June 1966," University of Chicago, Lemont, Ill.

Air monitoring

Air-filter samples were collected continuously at seven locations on the Argonne site and at five locations off the site. At one location on the site the filter paper was changed daily; at all other locations the filter papers were changed weekly.

Higher activities on the site are indicative of radioactivity released by Argonne if the differences are greater than the 10 to 20 percent sampling and counting error. The total alpha and beta radioactivities in the weekly samples are summarized in table 1. The alpha radioactivity at all locations was not significant and was in the range found in previous years. The beta radioactivity was due primarily to fission and neutron activation products from nuclear detonations. Until May 15, this radio-

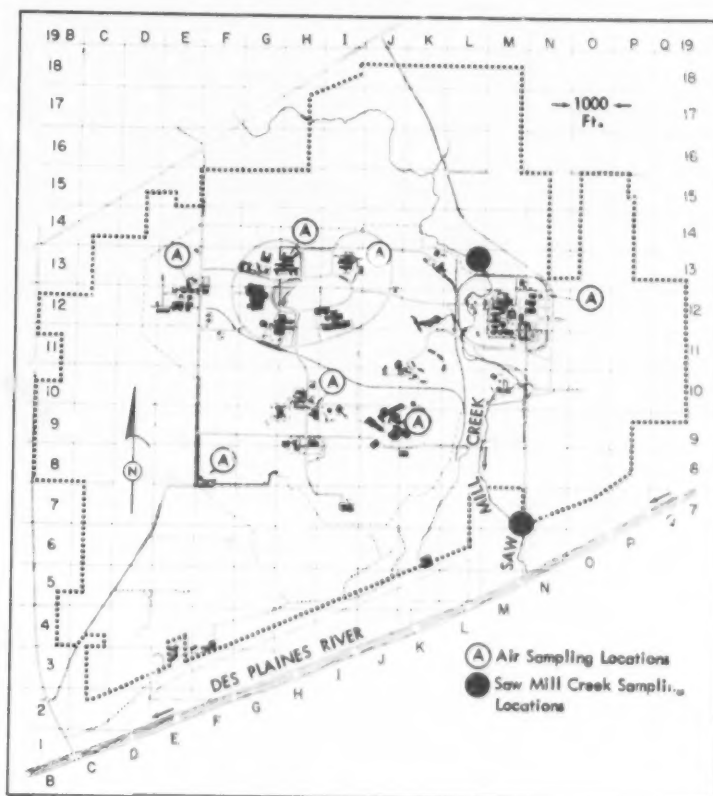


Figure 1. Sampling locations on the site of Argonne National Laboratory

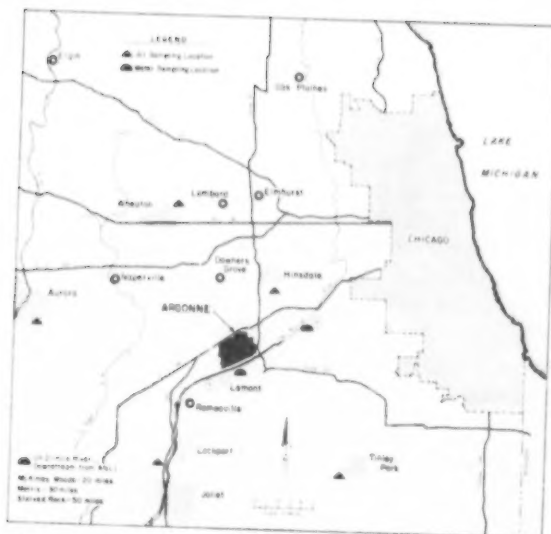


Figure 2. Site location of Argonne National Laboratory (including some offsite sampling stations)

activity was relatively low and unchanged from the last quarter of 1965. Beginning May 15, the beta radioactivity increased significantly and, at the same time, short-lived fission products (such as zirconium-95 and barium-140) were found in air samples from all locations. These changes were attributed to fallout from the mainland China test of May 9, 1966.

The presence of short-lived, and therefore recently produced, fission products was even more readily detectable in rainwater. While the air activities increased by a factor of about three, the radioactivity in rain increased from an average of 30 pCi/liter early in May to a maximum of 13,000 pCi/liter on May 18, and

then decreased to an average of 6,000 pCi/liter during the last half of May and 350 pCi/liter during June.

The average beta radioactivity in air during the first half of 1966 was 0.14 pCi/m³, which was about one-third of the average during the corresponding period in 1965. The similarity between alpha and beta radioactivities onsite and offsite indicates that Argonne did not add significantly to the airborne radioactivity of the environment during this period. The concentrations of specific fission products given in table 2 support this conclusion. Significant releases by Argonne would have been detected in the form of an increase in the onsite activity over the offsite activity.

In addition to the collection of air-filter samples, continuous sampling for gaseous radioiodine with activated charcoal was conducted in the "300 area" on the Argonne site (figure 1) because of the possibility of iodine releases in this area. Iodine-131 was present only in those samples collected from May 15 through June 3, at an average concentration of 0.1 pCi/m³ (0.1 percent of the MPC). This activity is also attributed to the mainland China test on the basis of the time of its appearance and disappearance.

Water monitoring

Argonne waste water is discharged into Sawmill Creek, a stream that runs through the Argonne grounds and enters the Des Plaines River about 500 yards downstream from the wastewater discharge. Sawmill Creek was sampled above and below the discharge to evaluate the effect of the wastewater on the

Table 1. Total alpha and beta radioactivity in air-filter samples^a, Argonne National Laboratory, January-June 1966

Month 1966	Location	Number of samples	Alpha radioactivity (pCi/m ³)			Beta radioactivity (pCi/m ³)		
			Average	Minimum	Maximum	Average	Minimum	Maximum
January	Onsite	22	0.0036	0.0026	0.0040	0.08	0.04	0.11
February	Offsite	18	0.0036	0.0025	0.0049	0.08	0.06	0.10
March	Onsite	21	0.0032	0.0018	0.0043	0.08	0.05	0.11
April	Offsite	18	0.0040	0.0025	0.0085	0.09	0.06	0.14
May	Onsite	27	0.0037	0.0015	0.0066	0.10	0.05	0.13
June	Offsite	20	0.0039	0.0025	0.0058	0.11	0.07	0.15
Summary	Onsite	27	0.0037	0.0010	0.0080	0.08	0.02	0.15
	Offsite	25	0.0031	0.0014	0.0061	0.09	0.05	0.16
	Onsite	20	0.0042	0.0020	0.0077	0.16	0.05	0.38
	Offsite	20	0.0056	0.0037	0.0090	0.17	0.06	0.27
	Onsite	18	0.0046	0.0026	0.0072	0.29	0.16	0.42
	Offsite	18	0.0046	0.0026	0.0072	0.33	0.19	0.50
Summary	Onsite	142	0.0042	0.0010	0.0090	0.13	0.02	0.42
	Offsite	117	0.0040	0.0014	0.0085	0.15	0.02	0.50

^a These results were obtained by measuring the samples 4 days after they were collected in order to avoid counting the natural radioactivity due to radon and thoron decay products. This activity is normally present in the air and disappears within 4 days by radioactive decay.

Table 2. Gamma-ray activity in air-filter samples, Argonne National Laboratory, January-June 1966

Radionuclide	Location	Radioactivity (pCi/m ³)						
		January	February	March	April	May	June	Average
Antimony-125	Onsite	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
	Offsite	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
Barium-lanthanum-140	Onsite	<0.01	<0.01	<0.01	<0.01	0.04	0.04	0.02
	Offsite	<0.01	<0.01	<0.01	<0.01	0.04	0.04	0.02
Cerium-144	Onsite	0.01	0.01	0.02	0.02	0.03	0.03	0.02
	Offsite	0.01	0.01	0.02	0.02	0.03	0.03	0.02
Cesium-137	Onsite	0.01	0.01	0.01	0.01	0.02	0.02	0.01
	Offsite	0.01	0.01	0.01	0.01	0.02	0.02	0.01
Ruthenium-rhodium-106	Onsite	<0.01	<0.01	<0.01	0.01	0.01	0.02	0.01
	Offsite	<0.01	<0.01	<0.01	0.01	0.01	0.02	0.01
Zirconium-niobium-95	Onsite	<0.01	<0.01	<0.01	<0.01	0.01	0.03	0.01
	Offsite	<0.01	<0.01	<0.01	<0.01	0.01	0.03	0.01

radioactivity in the creek. The sampling locations are shown in figure 1. Below the wastewater outfall the creek was sampled three times weekly. Equal portions of the three weekly samples were combined into a composite sample and analyzed. The results obtained in this manner represent the average concentrations in the weekly samples. Above the site, samples were collected at weekly intervals, and at least one sample each month was analyzed for each radionuclide of interest. The total alpha and beta radioactivity found in Sawmill Creek during the first half of 1966 is given in table 3.

The concentration of alpha radioactivity in the creek resulting from the presence of Argonne wastewater can be estimated as follows: below the outfall, the natural creek flow supplemented with Argonne wastewater was approximately double the rate of flow above the outfall. Consequently, the average natural alpha radioactivity in the creek below the out-

fall was approximately one-half of the above-site radioactivity or about 1.1 pCi/liter, and the average radioactivity owing to wastewater was about 2.3 pCi/liter. This is similar to the corresponding value for 1965.

The alpha-emitting radionuclides most likely to be present in Argonne waste waters are isotopes of uranium, plutonium, and thorium. The alpha radioactivity resulting from these elements is summarized in table 4. A comparison of these concentrations with the total alpha radioactivity indicates that most of the alpha radioactivity added to the creek in Argonne wastewater was due to uranium. The uranium concentrations above the site were normal. Below the outfall, the wastewater added an average of about 1.4 pCi of uranium per liter, or 0.004 percent of the MPC. Small amounts of plutonium or thorium were present in about one-half of the water samples taken below the outfall. Since plutonium was not detected in

Table 3. Non-volatile alpha and beta radioactivity in Sawmill Creek water, Argonne National Laboratory, January-June 1966

Month 1966	Location *	Number of samples	Alpha radioactivity (pCi/liter)			Beta radioactivity (pCi/liter)		
			Average	Minimum	Maximum	Average	Minimum	Maximum
January	Upstream	4	2.2	1.8	2.6	7.1	6.5	7.8
	Downstream	15	2.8	1.3	5.7	20.0	12.1	41.7
February	Upstream	4	2.0	1.7	2.2	9.0	6.3	14.0
	Downstream	12	4.1	3.3	4.8	29.0	24.5	38.2
March	Upstream	5	2.7	1.5	3.9	9.1	7.2	10.4
	Downstream	13	5.4	2.4	12.7	41.6	14.0	99.3
April	Upstream	4	2.1	1.6	2.8	8.7	6.1	12.9
	Downstream	15	2.6	1.3	5.0	15.9	11.5	21.6
May	Upstream	3	2.4	2.0	2.8	14.8	7.8	21.3
	Downstream	12	3.4	2.1	6.5	17.1	12.7	25.6
June	Upstream	5	1.3	0.1	2.3	10.3	8.2	14.0
	Downstream	12	2.2	2.0	2.6	14.3	12.7	17.0
Summary	Upstream	25	2.1	0.1	3.9	9.8	6.1	21.3
	Downstream	79	3.4	1.3	12.7	23.0	11.5	99.3

* Relative sampling location with respect to Argonne wastewater outfall (figure 1)

Table 4. Alpha-emitting elements in Sawmill Creek water, Argonne National Laboratory, January-June 1966

Element	Location *	Number of samples	Concentration, pCi/liter			Percent of MPC	
			Average	Minimum	Maximum	Average	Maximum
Uranium.....	Upstream.....	10	1.4	0.8	2.2	0.004	0.006
	Downstream.....	75	2.1	1.4	5.1	0.005	0.013
Plutonium.....	Upstream.....	6	<0.05	<0.05	<0.05	<0.001	<0.001
	Downstream.....	72	0.42	<0.05	8.0	0.008	0.16
Thorium.....	Upstream.....	6	0.05	<0.05	0.12	0.003	0.006
	Downstream.....	72	0.06	<0.05	0.28	0.003	0.014

* Relative sampling location with respect to Argonne wastewater outfall (figure 1).

the creek above the site, its presence below the outfall was evidently due to the wastewater. Thorium was present at both locations at about the same average concentration, although a few below-outfall samples had a thorium content high enough to attribute its presence to the wastewater. The concentrations of thorium and uranium were similar to those found at the same locations in 1965. The plutonium concentration below the outfall averaged about five times higher than during 1965, but this increased average was due almost entirely to one sample collected during the week of March 23, 1966, which contained 8 pCi of plutonium per liter.

In addition to the natural beta radioactivity in the creek, beta radioactivity from nuclear detonations was detected at both sampling locations and beta radioactivity from Argonne wastewater was found in some samples below the outfall. The natural beta radioactivity is approximately 5 pCi/liter above the site and 3 pCi/liter below the site. The Argonne contribution to the total beta radioactivity below the outfall during the first half of 1966 is estimated to be 10 to 15 pCi/liter. The remaining

radioactivity at both locations, about 5 pCi/liter, was attributed to fallout. The concentration of fallout radioactivity was approximately one-half of the 1965 average, while the Argonne contribution to the total beta radioactivity increased by a factor of about two.

Beta radioactivity from Argonne wastewater (in amounts very low compared with the MPC's) was found in some samples of Sawmill Creek water collected below the laboratory outfall. The concentrations of radioactive materials at this location are summarized in table 5. A comparison of these concentrations with those from samples obtained above the outfall indicates that cesium-137, cerium-144, cobalt-60, hydrogen-3, technetium-99, and thorium-protactinium-234 (decay products of uranium-238) can definitely be attributed to Argonne wastewater. Technetium-99 was detected in only one sample. The short-lived fission products, strontium-89 and barium-140, were evidently present as a result of fallout only.

The origin of the strontium-90 below the outfall is difficult to determine since the concentrations were similar at both locations and since this radionuclide is added to below-outfall

Table 5. Beta radioactivity in Sawmill Creek below wastewater outfall, Argonne National Laboratory, January-June 1966

Radionuclide	Number of samples	Concentration (pCi/liter)			Percent of MPC	
		Average	Minimum	Maximum	Average	Maximum
Barium-140.....	78	<2	<2	<2	<0.007	<0.007
Cerium-144.....	78	<10	<10	56	<0.1	0.56
Cesium-137.....	78	1.5	<0.5	2.8	0.008	0.014
Cobalt-58.....	78	<5	<5	<5	<0.005	<0.005
Cobalt-60.....	78	2.2	ND	7.2	0.004	0.014
Hydrogen-3.....	78	<4	<4	11	<0.13	0.37
Iodine-131.....	36	<3	<3	<3	<1	<1
Strontium-89.....	78	<2	<2	2.9	<0.07	0.10
Strontium-90.....	78	2.1	0.9	4.8	0.7	1.6
Technetium-99.....	78	<0.5	<0.5	0.6	<0.0002	0.0002
Thorium-protactinium-234.....	75	1.7	1.1	4.1	0.009	0.021

* Multiply by 10³.
ND, no data reported

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water directly from the atmosphere (as fallout) as well as by above-outfall water. However, the Argonne contribution must have been smaller than the fallout contribution.

Since Sawmill Creek empties into the Des Plaines River, which in turn flows into the Illinois River, the radioactivity in the latter two rivers is important in assessing the contribution of Argonne wastewater to the environmental radioactivity. The Des Plaines River was sampled weekly, except when the creek was dry, above and below the mouth of Sawmill Creek to determine if the radioactivity in the creek had any effect on the radioactivity in the river. Samples were also obtained at three locations on the Illinois River on May 12 and analyzed for total radioactivity. The average total radioactivity in these two rivers is summarized in table 6 for the first half of 1966.

Table 6. Average radioactivity in Des Plaines and Illinois River water, Argonne National Laboratory, January-June 1966

Location	Concentration, pCi/liter	
	Non-volatile alpha radioactivity	Non-volatile beta radioactivity
Des Plaines River * (above Sawmill Creek) . . .	2.9	14
Des Plaines River b (below Sawmill Creek) . . .	2.2	12
Illinois River *	4.1	12

* Sampled near Route 45, upstream from the mouth of Sawmill Creek.
 b Sampled near Lemont, downstream from the mouth of Sawmill Creek.
 * Average for samples collected at three locations (McKinley Woods State Park, Morris, and Starved Rock State Park) on May 12, 1966.

Dilution of Sawmill Creek water in the Des Plaines River was sufficient to reduce the radioactivity in the creek to undetectable levels in the river. The alpha radioactivity in the Des Plaines River was normal and in the range previously found. The natural beta radioactivity in the Des Plaines River is about 8 pCi/liter and the additional radioactivity, 2 to 25 pCi/liter after the mainland China test, resulted from fallout. The total radioactivity in samples of the Illinois River water collected on May 12

was similar to that found in other bodies of water in the area. No radioactivity originating at Argonne could be detected.

Milk monitoring

Three samples of raw milk produced in the area were collected monthly (except in May, when an additional collection was made after the appearance of fallout from the May 9 nuclear test) and analyzed for the fission products usually present. These fission products were all due to fallout from nuclear detonations and their presence in milk was not related to Argonne operations. The long-lived fission products, strontium-90 and cesium-137 were present in all samples. Their average concentrations were about 35 percent less than during the corresponding period in 1965. The short-lived fission products, strontium-89 and iodine-131, were not detected before May and evidently originated in the mainland China test of May 9, 1966.

Conclusions

Small amounts of several radioactive nuclides were added to Sawmill Creek in Argonne wastewater. The resulting radioactivity concentrations in the creek were well below the MPC's and did not constitute a health hazard. Radioactivity from Argonne operations was not found at any other location off the Argonne site.

Fallout from nuclear test detonations conducted before 1966 was found at locations and in all types of materials examined throughout the first half of the year. Fallout from the atmospheric test detonation conducted by mainland China on May 9 was detected beginning May 15, 1966.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January-June 1965	March 1966
July-December 1965	September 1966

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2. Atomics International January-June 1966³

*North American Aviation, Inc.
Canoga Park, California*

Atomics International, a division of North American Aviation, Inc., has been engaged in atomic energy research and development since 1946. The company designs, develops, and constructs nuclear reactors for central station and compact power plants, and for medical, industrial, and scientific applications.

The company world headquarters facility (WHF) is located in Canoga Park, Calif., approximately 23 miles northwest of downtown Los Angeles. The 290-acre Nuclear Development Field Laboratory (Santa Susana Facility), equipped with extensive testing facilities for the support of advanced nuclear studies, is in Ventura County in the Simi Hills approximately 29 miles northwest of downtown Los Angeles. The location of the above sites in rela-

tion to nearby communities is shown in figure 3.

The basic concept of radiological hazard control at Atomics International requires total containment of radioactive materials and, through rigid operational controls, minimizes effluent releases and external radiation levels. The environmental monitoring program provides a check on the effectiveness of radiological safety procedures and of engineering safeguards incorporated into facility design.

The environs of Atomics International headquarters and the Nuclear Development Field Laboratory (NDFL) are surveyed monthly to determine the concentration of radioactivity in typical soil, vegetation, and water samples. In addition, continuous environmental air monitoring at the sites provides information concerning particulate radioactivity.

Air monitoring

Environmental air sampling is conducted continuously at the headquarters and NDFL sites with automatic air samplers operating on 24-hour sampling cycles. Airborne particulate radioactivity is collected on HV-70 filter paper

³ Summarized from "Environmental Monitoring, Semiannual Report, January 1, 1966 to June 30, 1966," Atomics International.

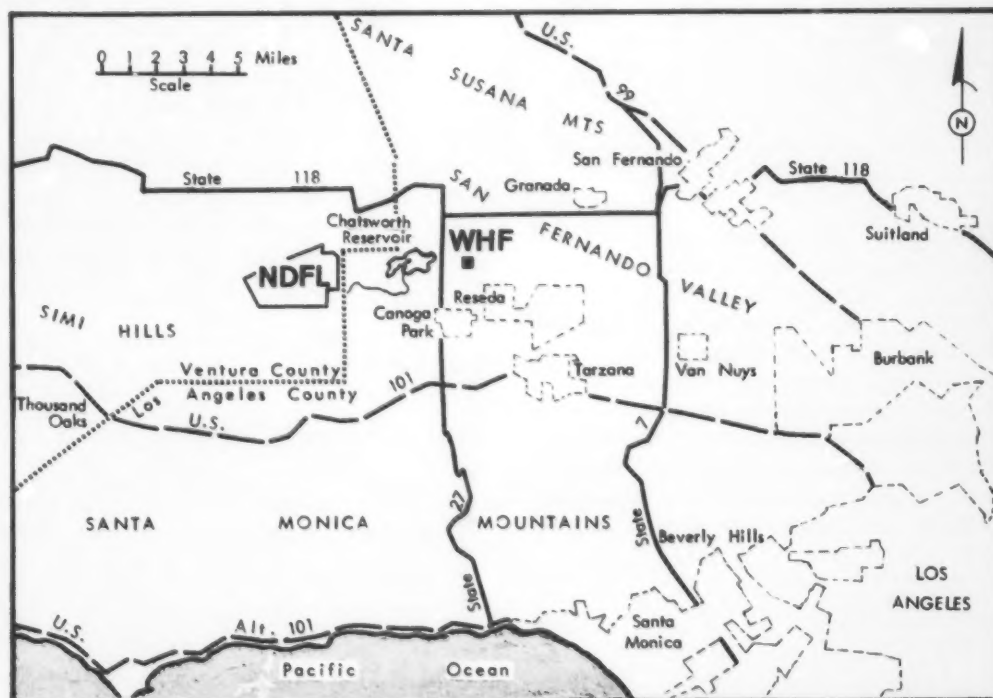


Figure 3. Atomics International facilities and vicinity

which is automatically changed at the end of each sampling period. The filter is removed from the sampler and counted after the radioactivity is allowed to decay for at least 72 hours. The volume of a typical daily environmental air sample is approximately 20 cubic meters. The average concentration of long lived beta-gamma radioactivity on airborne particulates is presented in table 7 for the calendar year 1965, and for the first half of 1966.

Table 7. Beta-gamma radioactivity of airborne particulates, Atomics International

Location	Calendar year 1965		First half 1966	
	Number of samples	Average radio-activity (pCi/m ³)	Number of samples	Average radio-activity (pCi/m ³)
Headquarters.....	483	0.83	360	0.14
NDFL.....	1,062	0.21	1,178	0.16

Water monitoring

Process-water used at the NDFL is obtained from wells and stored in two 50,000-gallon tanks. Potable water is delivered to the site by a vendor and is not analyzed. Well water is sampled monthly from the supply line at two locations. The average well-water radioactivity is presented in table 8.

Table 8. Well water radioactivity, Atomics International

Radiation	Calendar year 1965		First half 1966	
	Number of samples	Average radio-activity (pCi/liter)	Number of samples	Average radio-activity (pCi/liter)
Alpha.....	24	<0.22	12	0.11
Beta-gamma.....	24	<6.0	12	5.9

Soil, vegetation, and water are sampled monthly at Chatsworth Reservoir, which is operated by the Los Angeles City Department of Water and Power. Soil and vegetation radioactivity for the reservoir are averaged into data presented in tables 9 and 10. Normally, one water sample is obtained from the lake surface and a second sample is obtained from the reservoir water supply inlet located on the

Table 9. Radioactivity in the soil, Atomics International

Area	Radiation	Calendar year 1965		First half 1966	
		Number of samples	Average radio-activity (pCi/g)	Number of samples	Average radio-activity (pCi/g)
Onsite.....	Alpha.....	144	0.46	72	<0.39
	Beta-gamma.....	144	36	72	31
Offsite.....	Alpha.....	142	<0.47	24	<0.45
	Beta-gamma.....	142	29	24	25

Table 10. Radioactivity in vegetation, Atomics International

Area	Radiation	Calendar year 1965		First half 1966	
		Number of samples	Average radio-activity (pCi/g ash)	Number of samples	Average radio-activity (pCi/g ash)
Onsite.....	Alpha.....	144	<0.56	72	<0.40
	Beta-gamma.....	144	162	72	176
Offsite.....	Alpha.....	142	0.61	24	<0.39
	Beta-gamma.....	142	138	24	130

north side of the lake. The average radioactivity for both surface and supply water samples is presented in table 11.

Soil and vegetation monitoring

Soil and vegetation are sampled monthly at 24 locations. Twelve sampling stations are located within the boundaries of Atomics International's sites and are referred to as "onsite" stations. The remaining 12 stations, located within a 10-mile radius of the sites, are referred to as "offsite" stations.

Surface soil types available for sampling range from decomposed granite to clay and loam. Samples are taken from the top one-half inch layer of ground surface. The soil samples are packaged and sealed in plastic containers and returned to the laboratory for analysis. Data on radioactivity in soil samples are presented in table 9.

Vegetation samples obtained in the field are of the same plant type wherever possible, generally sunflower or wild tobacco plant leaves. These types maintain a more active growth rate during the dry season than do most natural plants indigenous to the local area. Leaves are stripped from plants and transferred to the

laboratory for analysis. Plant root systems are not routinely sampled. Radioactivity levels in vegetation samples are presented in table 10.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
First half 1965	March 1966
Second half 1965	September 1966

Table 11. Chatsworth Reservoir water radioactivity
Atomics International

Sample	Radiation	Number of samples	Average radioactivity (pCi/liter)	Number of samples	Average radioactivity (pCi/liter)
Lake surface	Alpha.....	11	0.65	6	0.38
	Beta-gamma..	11	8.7	6	6.6
Supply inlet...	Alpha.....	12	0.61	6	0.47
	Beta-gamma..	12	<9.1	6	6.9

3. Feed Materials Production Facilities January–December 1965⁴

Mallinckrodt Chemical Works Weldon Spring, Missouri

Environmental monitoring results at the Feed Materials Production Facilities (FMPF) are reported uranium concentrations since natural uranium ore concentrates constitute the primary feed material.

⁴ Summarized from "Semiannual and Annual Off-site Environmental Monitoring Report—1965," Weldon Spring Plant, Mallinckrodt Chemical Works, Uranium Division.

Process chemical wastes and other process residues are permanently retained in storage facilities located at the plant site (figure 4) and at two storage sites (one adjacent to the Lambert-St. Louis Municipal Airport and the other at a quarry near the Missouri River). The plant process-sewer, which carries the remaining water effluent from the operations into the Missouri River, is automatically sampled daily to permit continual measurement of any release of uranium-bearing materials into the river.

Air monitoring

Monthly air samples are collected along the Weldon Spring Plant perimeter (figure 5), at

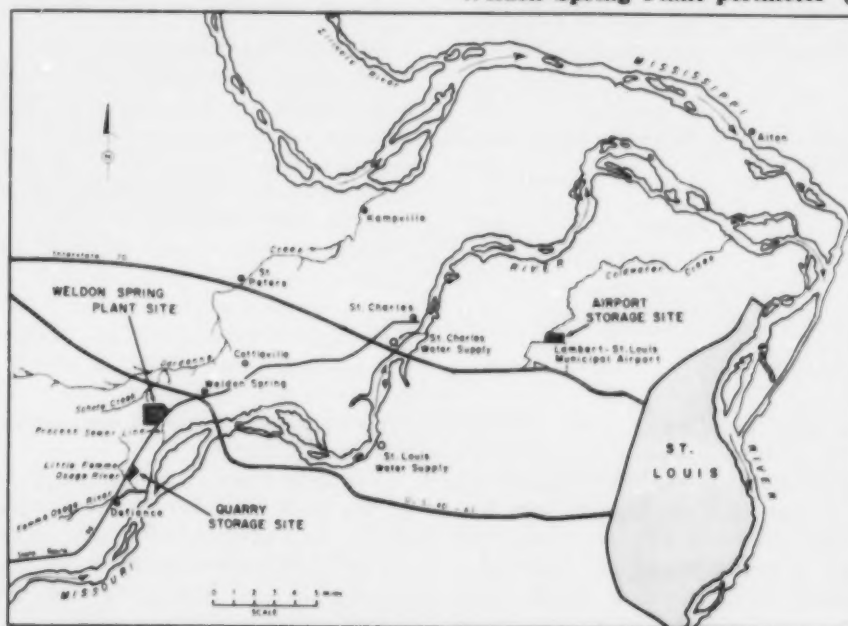


Figure 4. Location of Feed Materials Production Facilities, Weldon Spring

the water plant (2 miles southwest of the plant site), and at the south edge of the AEC quarry (figure 4) by high-volume air-sampling units. Semiannual air samples are also collected at four points on the perimeter of the airport storage site. The uranium concentrations detected in filtered air samples obtained during 1965 at FMPF are summarized in table 12.

**Table 12. Uranium concentrations in air
January-December 1965**

Site	Station location *	Number of samples	Uranium concentration (pCi/m ³)			Average as percent MPC
			Maximum	Minimum	Average	
Plant	1	9	0.38	0.02	0.15	8
	2	10	0.34	0.01	0.06	3
	5	8	0.34	0.03	0.13	6
	6	10	0.10	0.005	0.04	2
	Water plant	5	0.04	<0.01	0.02	1
Quarry	South edge	2	0.4	0.3	0.4	20
	North	2	0.2	0.001	<0.1	<
Airport	East	2	0.2	0.002	<0.1	<
	South	2	0.1	0.001	<0.1	<
	West	2	0.3	0.002	<0.1	<

* Refer to figures 4 and 5 for site and station locations.

The average uranium concentrations noted in perimeter air samples collected during the second half of 1965 increased slightly from the average obtained during the previous 1965 sampling period. The average uranium concentration in the filtered air samples, with the exception of the AEC quarry, continued to remain below one-tenth of the MPC for air.

Water monitoring

In addition to daily samples from the plant process sewer, periodic offsite water samples are collected from lakes and streams located within the plant's watershed, the Missouri River, and streams near the quarry and airport storage sites at the points indicated in table 13. Uranium concentrations ranged from 1.0 to 4.0 percent of the environmental MPC for samples obtained from the plant-process sewer. The mean uranium concentration for process sewer-water samples was 2.2 percent of the MPC.

Table 13. Uranium concentrations in water, January-December 1965

Sampling locations	Number of samples	Concentration (pCi/liter)			Average as percent MPC
		Maximum	Minimum	Average	
Weldon Spring Plant site:					
Process sewer	214	800	200	440	2.2
Plant offsite sampling points:					
Lake, east of plant	2	<10	<10	<10	<0.1
Lake, north of plant	2	20	<10	10	<0.1
Lake, west of plant	2	<10	<10	<10	<0.1
Lake, south of plant	2	20	10	15	<0.1
Dardenne Creek, upstream	2	<10	<10	<10	<0.1
Dardenne Creek, Cottleville bridge	2	<10	<10	<10	<0.1
Dardenne Creek, St. Peters' bridge	2	<10	<10	<10	<0.1
Dardenne Creek, Kampville bridge	2	<10	<10	<10	<0.1
Schote Creek, upstream	2	<10	<10	<10	<0.1
Schote Creek, downstream	12	20	<10	20	<0.1
Plant surface drainage, west	12	400	40	500	2.5
Plant surface drainage, north	12	600	10	300	1.5
Missouri River sampling points:					
Upstream at Defiance, Missouri	2	<10	<10	<10	<0.1
Upstream at Femme Osage junction	2	<10	<10	<10	<0.1
U.S. Highway 40-61, south side	2	<10	<10	<10	<0.1
St. Louis city water plant intake	2	<10	<10	<10	<0.1
St. Charles city water plant intake	2	<10	<10	<10	<0.1
Quarry offsite sampling points:					
Tributary of Little Femme Osage, 1/4 mile upstream	2	10	<10	<10	<0.1
Little Femme Osage, 1/4 mile upstream	2	10	<10	<10	<0.1
Little Femme Osage, at quarry discharge culvert	12	10	<10	<10	<0.1
Little Femme Osage, 1/4 mile downstream	2	<10	<10	<10	<0.1
Little Femme Osage, 1 1/4 mile downstream	2	<10	<10	<10	<0.1
Air port offsite sampling points:					
Cold Water Creek, southwest corner of site	2	<10	<10	<10	<0.1
Cold Water Creek, after site pond discharge	2	<10	<10	<10	<0.1
Cold Water Creek, northwest corner of site	2	<10	<10	<10	<0.1



Figure 5. Perimeter air sampling stations
Weldon Spring Plant

Water samples obtained from the Missouri River, with two exceptions, contained less than detectable uranium concentrations both above and below the MCW plant outfall. The exceptions were two samples obtained at the outfall, which averaged uranium concentrations of 0.2 percent of the MPC for uncontrolled areas. Six samples were obtained from the Missouri River sampling station immediately downstream from the outfall. Analysis of these samples yielded nondetectable concentrations of uranium.

Conclusions

The average uranium concentration of all offsite water and air samples collected during the year was 3.6 percent of the MPC, representing a slight increase from the 1964 average of 1.9 percent. The average release of uranium-bearing materials from the MCW Uranium Division was found to be substantially below the MPC for nonoccupational areas for natural uranium. Table 14 summarizes average uranium concentrations and percent of the MPC for samples collected during the first and second quarters and the year 1965.

Table 14. Average uranium concentration of environmental samples, January-December 1965

Source of samples	Average uranium concentrations as percent of nonoccupational MPC (pCi/liter)		
	First half	Second half	Year 1965
Weldon Spring Site:			
Process sewer.....	2	3	2.3
Lakes.....	<0.1	<0.1	<0.1
Drainage ditches.....	0.5	0.3	0.4
Missouri River (below operation).....	<0.1	<0.1	<0.1
Perimeter air.....	4	7	5
Airport site:			
Creeks and ditches.....	<0.1	<0.1	<0.1
Perimeter air.....	0.1	5	4
AEC Quarry site:			
Streams.....	<0.1	<0.1	0.1
Perimeter air.....	—	20	20

Recent coverage in *Radiological Health Data and Reports*:

Period
July 1962-December 1963
January-December 1964

Issue
May 1964
March 1966

4. National Reactor Testing Station January-June 1966²

Health and Safety Division
U.S. Atomic Energy Commission
Idaho Falls, Idaho

Data from the environmental monitoring network on and around the National Reactor Testing Station (NRTS) in eastern Idaho revealed that NRTS operations during the first half of 1966 did not contribute significantly to environmental radiation or radioactivity concentration levels, which remained well below levels defined as thresholds of concern by the Federal Radiation Council (FRC). The Radiation Protection Guides (RPG) and Radioactivity Concentration Guides (RCG) used at the NRTS, which are established in AEC Manual Chapter 0524, are based on FRC recommendations. No significant quantities of radium-226

² Summarized from "Environmental Monitoring Report No. 18, First and Second Quarter 1966," U.S. Atomic Energy Commission, Idaho Operations Office, Health and Safety Division, National Reactor Testing Station.

or radium-228 have been released to the environment by NRTS operations. The concentrations of radioactivity reported include contributions from all sources. No attempt has been made to separate radioactivity contributed by NRTS operations from that contributed by natural sources of radioactivity or by fallout from weapons debris. Samples of air, water, and milk are collected routinely at stations shown in figure 6. During the growing season, wheat samples are collected routinely at locations shown in figure 6. The results of the analyses performed on these samples are shown in table 15.

Aerial survey

Results obtained from a detailed aerial survey performed over the NRTS in early 1966 confirmed similar measurements obtained in 1959, and again showed no significant change in environmental radiation background that could be attributed to NRTS operations. Radiation measurements were made along parallel courses 1 mile apart at 500 feet altitude. The survey was performed by an AEC contractor who

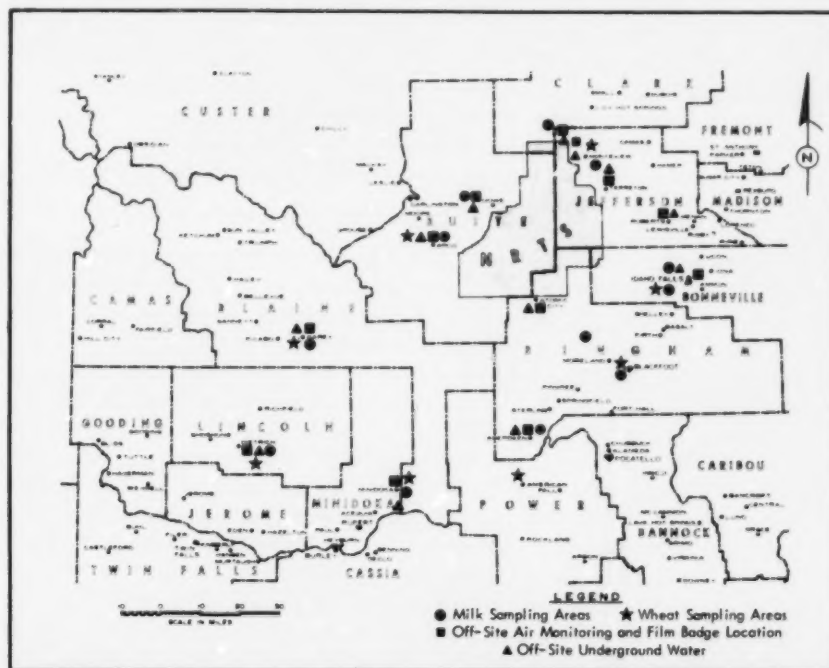


Figure 6. Environmental monitoring stations, National Reactor Testing Station

Table 15. Environmental monitoring program data, NRTS, January-June 1966

Type of sample and units	Number of stations	Approximate frequency of collection	Type of analysis	Minimum level of detection	Maximum activity of single sample	Average activity per sample	Radioactivity concentration or Radiation Protection Guides
Offsite underground water,* pCi/liter	12	Semi-annual	Alpha Beta	3 6			100
Onsite production well water, pCi/liter	22	Semi-monthly	Alpha Beta	3 6	6 125	<4 <9	3,000 3,000
Offsite air, pCi/m ³	12	Continuous	Beta-gamma Iodine-131	1.6 3.6	32 60	<8 <5	100 100
Offsite milk, pCi/liter	12	Monthly	Iodine-131 Strontium-90	20 1.5	30 17	<21 <11	100 200
Offsite area monitoring badges, mR	12	Monthly	Gamma	10	<10	<10	170/yr

* Due to changes in sample locations and procedures no data is available for this reporting period.

operates a specially equipped aircraft capable of detecting trace quantities of radioactivity and identifying the material detected. Small variations in the natural background were again noted over varying terrain and were clearly identified with naturally occurring radioactivity in rock and soil formations.

Offsite water monitoring

Low-level liquid wastes from various operating facilities at the NRTS are released to the ground-water table through disposal wells and ponds located near each facility. Before disposal the liquid wastes are carefully monitored at the NRTS and, as an added safeguard, offsite underground water samples are collected and analyzed regularly. Most of these samples are taken from the area southwest of the NRTS, the prevalent direction of underground water flow. Since the beginning of the offsite sample collections in 1952, there has been no evidence of any NRTS contribution to the natural radioactivity in the offsite water.

Through continuing studies of the underground water on the NRTS, additional knowledge of the directional flow and flow rates have been obtained. As a result of this knowledge the number and locations of sampling points have been reduced to those populated areas nearest the site boundaries. Samples from these locations, as shown on the accompanying map, plus the onsite samples are expected to provide adequate information on the underground water leaving the NRTS.

Because of the changes in sampling procedure, no data are available for this reporting period, except for the onsite samples taken at down-gradient locations between the points of discharge and the site boundary.

Onsite water monitoring

Onsite samples were taken from the plant production wells in order to detect and define possible sources of contamination. During the first half of 1966, 215 samples were collected from 22 sampling stations, most on a biweekly basis. Analyses of these samples showed that average concentrations of alpha and beta emitters were no more than 0.2 percent and 0.3 percent of their respective RCG values.

Offsite air monitoring

Normal operations of the present radio telemetry system call for hourly reports by each station. The reporting instruments and functions are:

1. Ion chamber: this instrument measures ambient radiation levels in mR/hr.
2. GM counters: HV-70 filter paper, which collects airborne particulate, is cycled to a GM tube once a day. One GM tube measures the buildup of particulate radioactivity during the day and another measures the decay of the radioactivity collected the previous day.
3. Scintillation counter: air, which has previously passed through the HV-70 particulate filter passes through a carbon cartridge. For surveillance purposes, the radioactivity which is measured hourly is assumed to be iodine-131.

This cartridge remains in place for periods up to 6 weeks.

Results of the data reported from the 15 radiation telemetry stations indicate that the average concentrations of gaseous iodine-131 and particulate radioactivity in the atmosphere were less than 8 percent of the RCG value for the first half of 1966.

Offsite milk monitoring

Routine analyses of iodine-131 and strontium 90 concentrations in milk continued on a monthly basis during the first half of 1966. Of the 68 routine radioiodine analyses, only 3 samples were found to have concentrations greater than 20 pCi/liter. As indicated in table 15, the average iodine-131 levels do not exceed 21 percent of the RCG values. Strontium-90 concentrations in the same 68 samples showed the maximum activity to be 17 pCi/liter, or less than 9 percent of the RCG value with an average value of only 6 percent.

Area monitoring badges

Offsite film badges were collected on a monthly basis during the first half of the year. The

maximum radiation exposure at a single location for any month as measured by film was <10 mR of gamma radiation. The minimum detection limit for the 6 months was 60 mR of gamma radiation, based on six film changes and a detection limit of 10 mR gamma radiation on each film. For the purpose of calculating the maximum exposure, each statistically zero result was assumed to be at the detection limit. The reported maximum is therefore conservatively estimated to be the upper limit of the true exposure at that location. Natural background radiation levels at film badge locations vary, but studies made prior to nuclear operations at the NRTS showed that normal background levels were of the order of 100-150 mR/yr. This indicates that NRTS operations have added no significant radiation to surrounding areas.

Recent coverage in Radiological Health Data and Reports:

<u>Period</u>	<u>Issue</u>
January-June 1965	March 1966
July-December and calendar year 1965	September 1966

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Section V. Technical Notes

REPORTED NUCLEAR DETONATIONS, FEBRUARY 1967

During February 1967, three U.S. nuclear tests were reported; on February 8 and February 23, underground nuclear tests of low yield (less than 20 kilotons TNT equivalent) were conducted by the U.S. Atomic Energy Commission at its Nevada test site. Also on February 23, an underground nuclear test of low-intermediate yield (20 to 200 kilotons TNT equivalent) was conducted by the U.S. Atomic Energy Commission at its Nevada test site.

This is the first time since December 1965 that the Atomic Energy Commission has announced two such tests in a single day.

On February 25, the United States recorded seismic signals which originated from the Soviet nuclear-test area in the Semipalatinsk region. The signals were equivalent to those of a nuclear test in the intermediate-yield range (200 kilotons to 1 megaton TNT equivalent).

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SYNOPSIS

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

RADIATION HAZARDS IN URANIUM MINES. *D. A. Holaday.*
Radiological Health Data and Reports, Vol. 8, March 1967, pp. 135-138.

A review of health studies of U.S. uranium miners is presented. The primary radiation hazard in these uranium mines is alpha radiation which is delivered to the lungs by the short-lived daughters of radon. The appearance of lung cancer among uranium miners has been studied and was found to be excessive. The cell-type distribution of these cancers is different from that of the general population. Calculation of radiation dosage to the lungs of miners is difficult.

General dilution ventilation is the primary method of controlling the radiation hazard, but it has limitations. Radiation exposure of uranium miners has gradually been reduced.

KEY WORDS: exposure, lung, lung cancer, mines, miners, radiation hazards, radon daughters, radon-222, smokers, uranium, uranium mines.

ERRATUM

The last equation appearing in the article "Precision and Sensitivity of Gamma Spectrometric Measurements in Milk" (Radiol Health Data Rep 7: 555-559, October 1966) should be amended. The second part of equation (6) on page 556 should read as follows:

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